

LICHENS OF MINNESOTA
 HISTORY OF COCONUT PALM
 GRAMA GRASSES.

ADVERTISEMENT.

The United States National Herbarium, which was founded by the Smithsonian Institution, was transferred in the year 1868 to the Department of Agriculture and continued to be maintained by that department until July 1, 1896, when it was returned to the official custody of the Smithsonian Institution. The Department of Agriculture, however, continued to publish the series of botanical reports entitled "Contributions from the United States National Herbarium," which it had begun in the year 1890, until on July 1, 1902, the National Museum, in pursuance of an act of Congress, assumed responsibility for the publication. The first seven volumes of the series were issued by the Department of Agriculture.

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*Assistant Secretary, Smithsonian Institution,
in charge of the United States National Museum.*

SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM

CONTRIBUTIONS

FROM THE

UNITED STATES NATIONAL HERBARIUM

VOLUME 14

LICHENS OF MINNESOTA
HISTORY OF COCONUT PALM
GRAMA GRASSES

FINK, COOK, GRIFFITHS



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PREFACE.

The first of the three papers which make up volume 14 of these Contributions is an extended work on the Lichens of Minnesota, by Prof. Bruce Fink, now of Miami University, Oxford, Ohio. This account is the result of several summers' fieldwork in Minnesota, under the auspices of the Geological and Natural History Survey of that State, together with studies in his own laboratory and at the National Herbarium. The lichen flora of Minnesota is fairly representative of the lichen flora of a large portion of northern North America, from the Atlantic to the Pacific. This publication, therefore, will be useful to students over a much wider area than that which it specifically covers. A series of the specimens enumerated in the catalogue of species is deposited in the United States National Herbarium. In the bibliographical work Prof. Fink was assisted by Mr. P. L. Ricker, of the United States Department of Agriculture. The bibliography of the works consulted in the preparation of the paper was prepared by Mr. Ricker.

The second paper, by Mr. O. F. Cook, of the Department of Agriculture, is a continuation of his study on the origin and distribution of the coconut palm, published in volume 7 of the Contributions. Much additional historical and botanical evidence is offered, tending to show even more conclusively than before that the coconut palm is a native of South America, and that it was carried westward across the Pacific in prehistoric times, instead of originating in the East Indies, as De Candolle and other botanical authorities have supposed.

The remaining paper, by Mr. David Griffiths, of the Department of Agriculture, is a systematic account of the grasses of the genus *Bouteloua* and closely related genera, chiefly of the species found in North America. These are native grasses, some of them among the most important constituents of the natural pasturage of the West. Mr. Griffiths, in the 11 years since the beginning of his study, has had extensive opportunity for the observation of these grasses in the field, chiefly as engaged in the investigation of the public stock ranges for the Department of Agriculture; has examined the specimens in the United States National Herbarium and several other large herbaria; and, for the study of the results obtained by others and the settlement of questions of nomenclature, has had at hand the excellent botanical resources of the Washington libraries.

FREDERICK V. COVILLE,
Curator of the United States National Herbarium.

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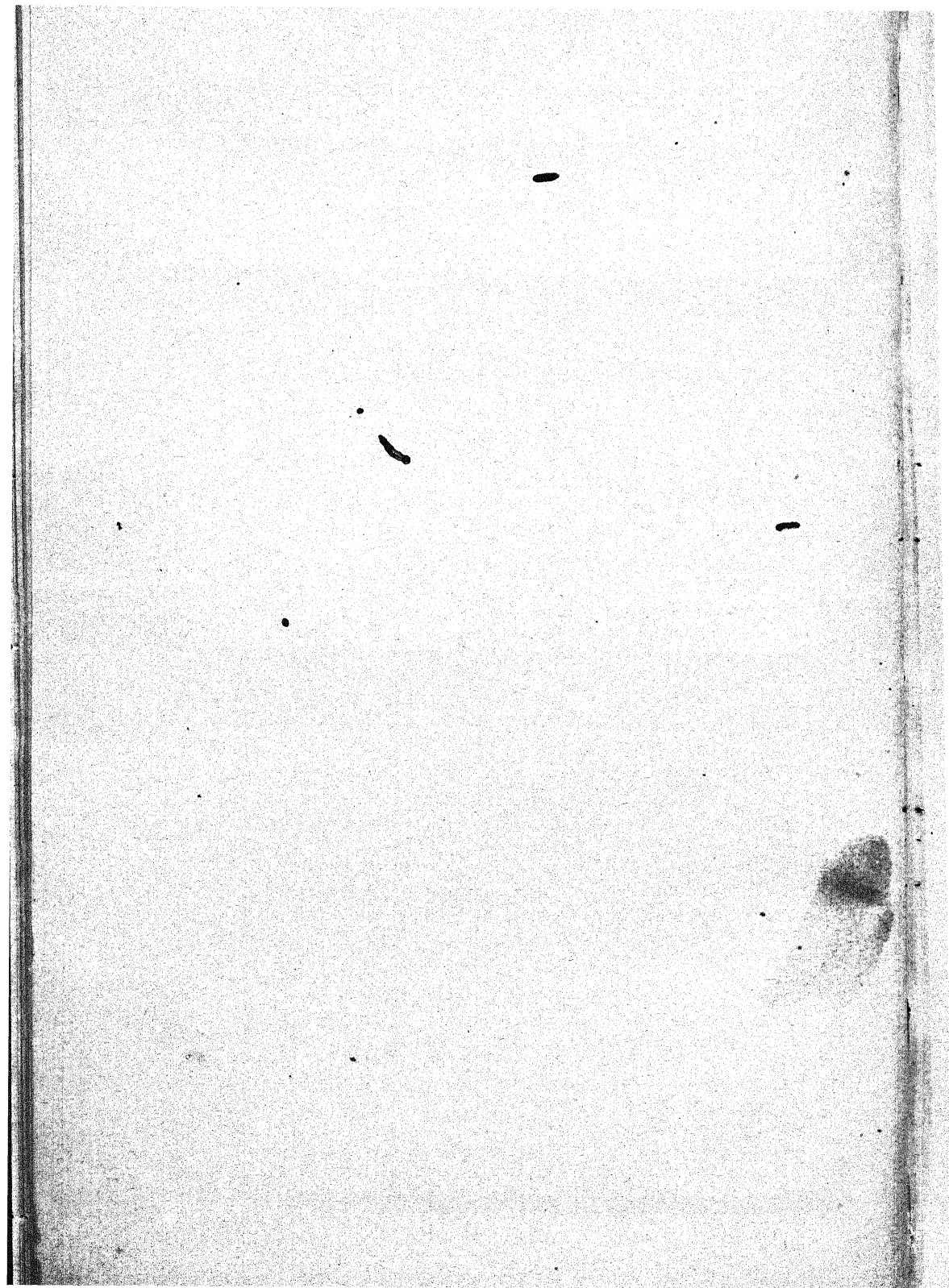
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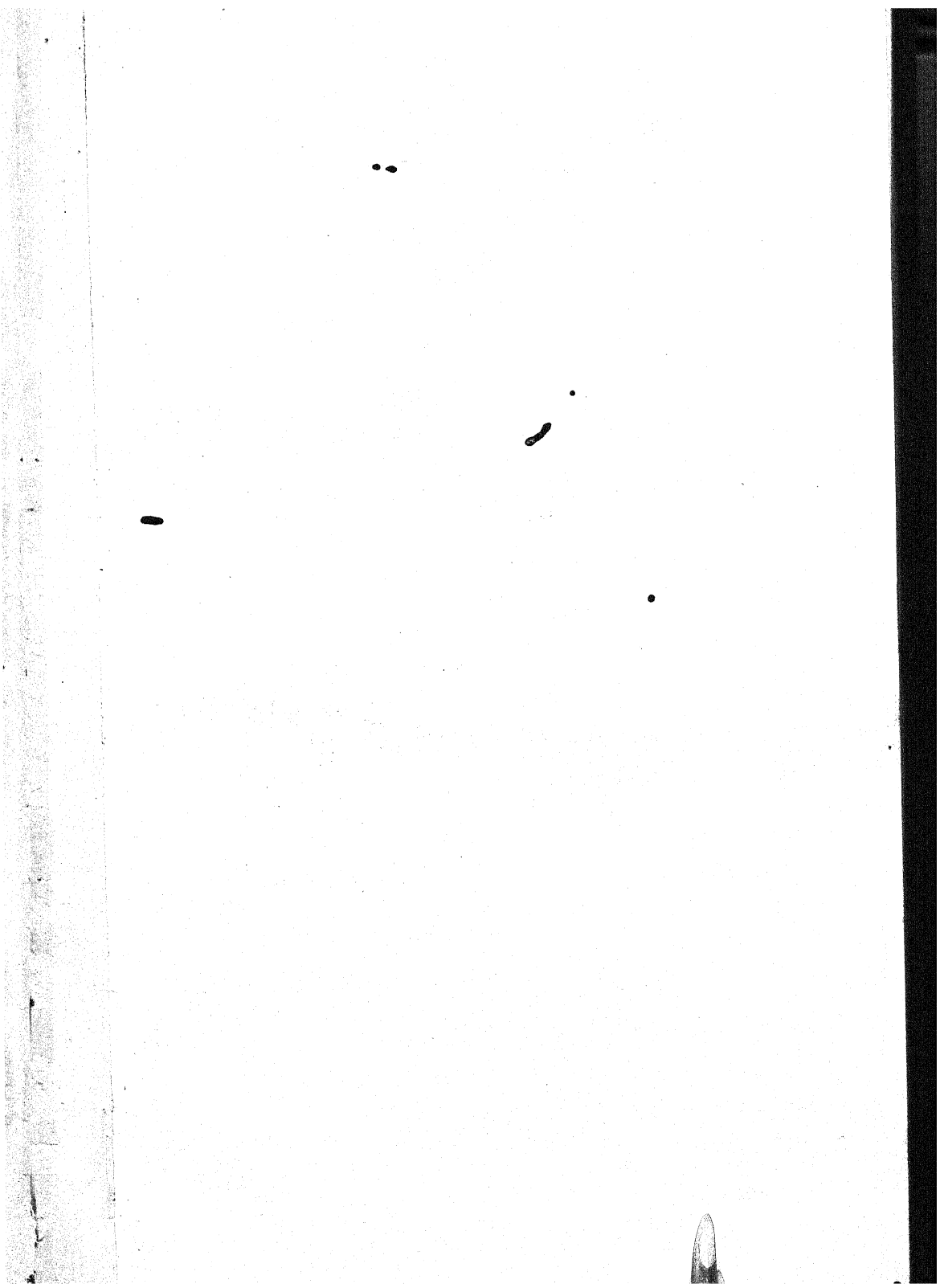
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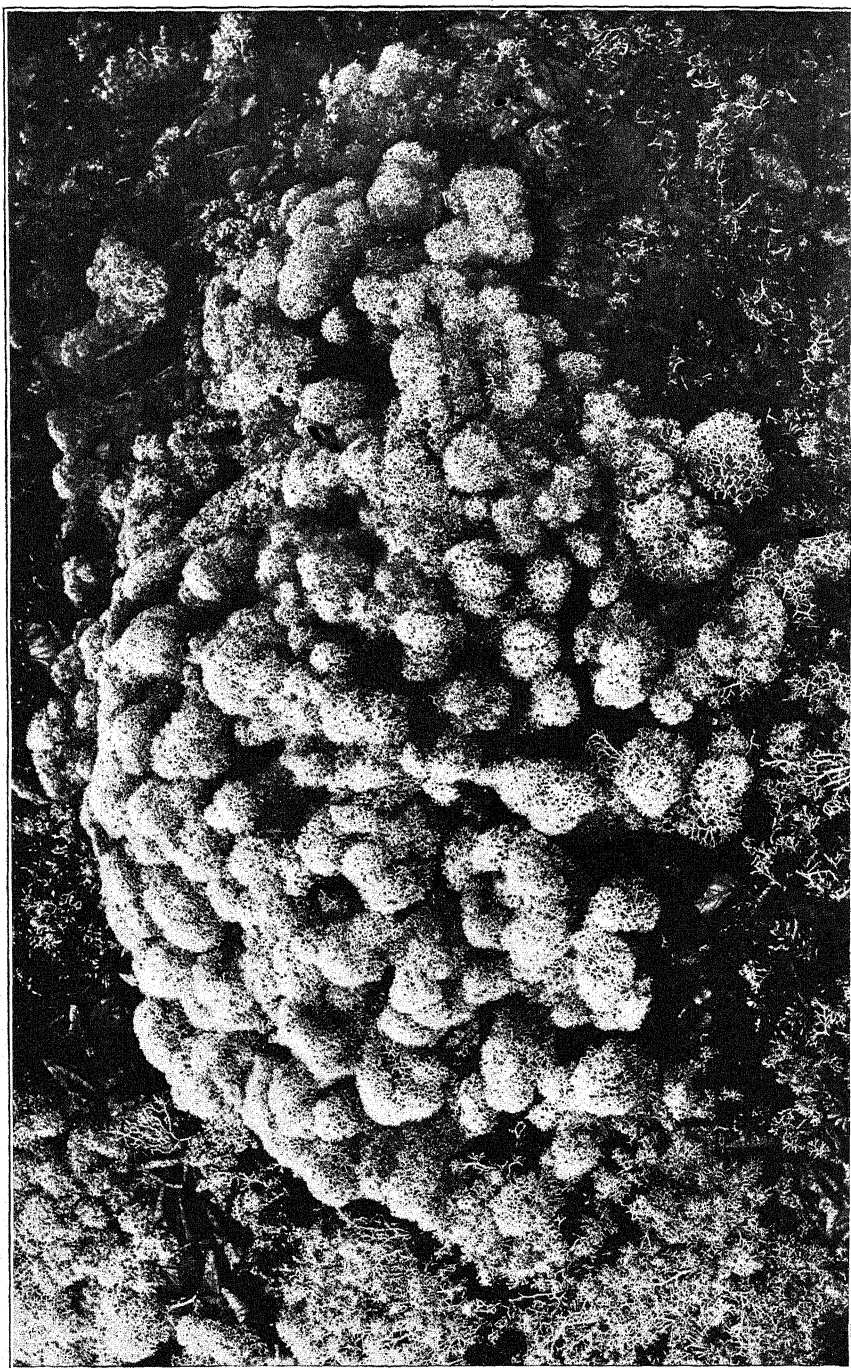
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CLADONIA ALPESTRIS (L.) RABENH.

THE LICHENS OF MINNESOTA.

By BRUCE FINK.

INTRODUCTION.

BASIS AND AIMS OF THE PRESENT WORK.

The author began his investigation of the lichen flora of Minnesota during the summer of 1896 and finished the work in the field during the summer of 1902. The preparation of the descriptive catalogue offered herewith has been in progress since the latter date. During the course of the field work seven papers were published in the Minnesota Botanical Studies, which are referred to in the present work as the "preliminary reports." Their full titles will be found in the bibliography at the close of the introduction.

The data of distribution as given in the preliminary reports could not be incorporated in full in the catalogue, but in case of species known only from one, two, or three places the specific localities are cited. Local students are referred to the reports mentioned for more complete information. To these reports also, the reader must be referred for matter relating to geographical and ecological distribution until it becomes possible to publish the fuller data on these subjects already brought together.

The aim in the catalogue has been to furnish descriptions and keys adapted to the use not only of specialists but also of younger students. To this end it has been the endeavor to avoid technicality so far as is consistent with clear presentation.

One of the faults of existing descriptions of lichens is their failure to give measurements of the size of thalli. Such measurements can only be approximate, often including neither the smallest nor the largest specimens that actually occur; but even so it is believed that they will greatly aid in the determination of the species, and they are accordingly here supplied. Another error on the part of some authors, found especially in brief descriptions, consists in the arbitrary definition of characters, leading the student to expect a constancy as to size, form, and color which does not exist in lichens. The attempt has been made in the present descriptions to state these variations as accurately as possible. While the catalogue treats of the lichens of

a single State, lichen species in general are so widely distributed that the descriptions and figures will, it is hoped, prove helpful in the determination of lichens throughout North America, and especially throughout the northern United States and British America.

As the method of determining the application of generic names of lichens is still in controversy, it has seemed best to use them in the traditional sense, stating the types of the genera according to the "first species" rule. In instances in which the type falls without the genus as at present understood, statement is made to that effect. It is manifest that, until there is general agreement as to a method of typifying genera and until all the nominal lichen genera have been typified according to this method, anything done toward a revision of the generic names would as likely as not have to be done over. Likewise, until lichen species have been typified as exhaustively as possible, any extended synonymy of them can be of little value. Consequently, nothing has been attempted in the way of synonymy of the species described, beyond stating, in instances in which a species has been transferred from the genus in which it was first described, the citation for the first combination as well as for the one used herein. The priority of specific names can be settled only by the examination of a large number of type specimens in European herbaria, and as the author has not been able to see these, there is no doubt that at least a small portion of the specific names here used will eventually have to give way to others.

Until we know more regarding the phylogeny of lichens and the structure of sexual reproductive tracts, anything approaching finality in their taxonomy is scarcely possible. The writer has been influenced in classification by a number of authors, especially by A. Zahlbruckner in Engler and Prantl, but holds himself alone responsible for the arrangement of families and genera used. In fixing upon the sequence of genera and of closely related families, both spore characters and vegetative structure have been taken into account. Doubtless the concurrent resemblance in these two respects is often merely accidental and it does not therefore always imply the close relationship that juxtaposition would indicate. These difficulties arising from this circumstance can only be settled by future investigations of anatomy, reproductive processes, and phylogeny.

It need scarcely be stated that the descriptive catalogue is the main feature of this work and that the preceding chapters, treating very briefly of the origin and nature, the morphology, the reproductive processes, and the uses of lichens, are intended as an aid in using it. It has, therefore, not been thought necessary to add a list of references to this part of the lichen literature.

The writer takes this opportunity to express his thanks to several persons who have aided in the work in various ways. First of all, he

is under obligation to Prof. Conway MacMillan for placing at his disposal facilities which made possible the work of the survey and preliminary study as well as the earlier work of preparation. His thanks are also due to the Board of Regents of the University of Minnesota for the privilege of using this material, prepared by himself in large part while a member of the botanical survey of Minnesota for publication elsewhere.

The later work of preparation was done at Washington, where chiefly the library of the United States Department of Agriculture afforded a large amount of literature used in verifying citations to species and in ascertaining the types of the genera. Thanks are due to Mr. Frederick V. Coville for many helpful suggestions regarding the work. The writer wishes especially to express his thanks to Mr. P. L. Ricker for aid in literary work connected with citations. Besides the libraries at Washington, the Lloyd Botanical Library at Cincinnati was much used, and the writer is under special obligations to the owners for access to this library, as he is also to the librarian, Mr. William Hadden, for many favors while working there. The writer's private library, the botanical library of the University of Minnesota, and that of the Missouri Botanical Garden were used during the early part of the work of preparation, and rare volumes were borrowed from various other libraries toward the close of the work, until all citations were verified.

Thanks are also due to Dr. E. Wainio, of Helsingfors, Finland; to Dr. A. Zahlbruckner, of Vienna; to L. Scriba, of Höchst a. Main, and to Dr. T. Hedlund, of Upsala, Sweden, for comparing specimens with authentic material and aiding in difficult determinations. Dr. W. G. Farlow, Dr. G. Lindau, of Berlin, and Doctor Zahlbruckner have also aided very kindly in the matter of citations. It is in order also to express appreciation of the services of Mr. C. J. Hibbard, in taking, under the author's direction, the photographs of lichens as they occurred in the field, from which the greater portion of the illustrations are reproduced.

Of the other illustrations thirteen plates and four text figures are reproduced from Schneider's Text-book of General Lichenology, for the privilege of using which thanks are due to Dr. N. L. Britton. Plate 16 is from an electrotype kindly loaned by Mrs. A. M. Smith, editor of the *Bryologist*, in which the plate was originally published. Nine text figures are reproduced by the kind permission of Dr. J. Reinke, of Kiel, Germany, from Pringsheim's *Jahrbücher*, volume 28. Of the remaining figures two are by permission from Sachs's Text-book of Botany, two from Stahl's *Geschlechtliche Fortpflanzung der Collemaceen*, and one partly from De Bary's *Comparative Anatomy* and partly from Tulasne. The sources of the nonoriginal illustrations are indicated under each.

Several students of the writer have aided materially by careful studies, under supervision, of many of the species described herein for details of microscopic structure and in subjecting portions of the manuscript to the test of use before publication. To all these the writer wishes to express his thanks.

Full sets of specimens of the species described herein may be found in the United States National Herbarium, the herbarium of the University of Minnesota, and the writer's private herbarium.

Below is given a list of the works hitherto published containing matter regarding the lichens of Minnesota.

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 - VII. Cladonia subcariosa, Cladonia mitrula, and Cladonia leptophylla. The Bryologist 9: 57-60. Jl. 1906.
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PRELIMINARY ACCOUNT OF LICHENS.

VIEWS AS TO THEIR ORIGIN AND NATURE.

Lichens have been at various times regarded as algæ, fungi, mosses, and liverworts, and Tournefort, in 1694, was the first botanist to classify them as a distinct group of plants. Subsequent study of anatomy and reproductive processes brought Tournefort's view into general favor, and the question of the place of lichens in the plant world was supposed to be settled. For nearly two centuries a literature of lichenology was growing up, based upon the unquestioned assumption that lichens are autonomies. Every botanist who does systematic work on lichens at present, whatever his opinions, must

use this literature, and it is therefore requisite to give some explanation of its leading conceptions and of the terms used.

There are in all lichens, at least at some period of their life, certain cells or chains of cells of a green color, or more rarely of a blue-green, brownish, or reddish color. If green, these cells were called "gonidia" (fig. 1, *a*, p. 9). If blue-green, they were called "gonimia" (fig. 1, *c*). Besides these cells or cell groups or filaments there are the well-known hyphæ of the lichen thallus, which have in the phylogenetic development of lichens very frequently become transformed in part into a parenchymatous structure, the cortex. In extreme instances, the whole hyphal structure has been transformed into cellular structure, while, on the other hand, in many of the lower lichens the cellular structure is entirely absent and the green or blue-green cells and the hyphæ compose the whole vegetative portion of the lichen. It was until recently supposed that the green or blue-green cells arose in the development of each lichen, probably from the hyphæ, and that the relation of the chlorophyllous to the hyphal portion of the thallus was the same as that of the chloroplasts of higher plants to other portions of the plant body. Thus both the green or blue-green cells and the hyphæ or equivalent parenchyma were regarded as integral parts of a single organism. It had long been known, however, that the green or blue-green cells in the lichen thallus are like certain algæ (figs. 1, 2, pp. 9, 10), and De Bary, the first botanist to investigate the resemblance carefully, advanced the suggestion that the alga-like cells of lichens might actually be algæ somewhat modified by peculiar conditions of existence. Schwendener, at first hostile to this suggestion, in 1868 announced his conviction, based upon the examination of lichen thalli, that the lichen is composed of two distinct portions, a fungal and an algal. Later investigations have established beyond doubt the main points of this view and have shown that the algæ in many lichens may be isolated, in which case they behave very much like similar free algæ. Some investigations of the fungal portions of lichens followed, and the conclusion was reached that the lichen could not be regarded as an autonomy at all, but must rather be considered a compound organism composed of a fungus and an alga, the two living together in the relation known as symbiosis.

Symbiosis, however, is of different kinds. It may exist with benefit to both organisms, the relation then constituting mutualism or mutualistic symbiosis; or it may exist with benefit to one of the symbionts and injury to the other, constituting parasitism or antagonistic symbiosis. In the early days of the investigation of symbiosis in lichens it was supposed that the fungus member which produced the fruit was benefited by the association while the alga was injured, the fungus thus being regarded as a parasite and on the alga as its host.

Setting out from this conception of the relationship of the two symbionts, botanists began to classify lichens as fungi.

In other instances of symbiosis than that found in lichens one or each of the symbionts is able to live quite independently of the other. In certain lichens the alga has been isolated from the association and has grown and produced reproductive bodies. Likewise the fungi forming some lichens have been isolated and have produced, in nutritive media, forms resembling the ordinary thalli of the lichen species. However, it may well be doubted whether either the fungal or the algal symbiont ever becomes free in nature and lives during its whole life period outside the symbiotic association. Thus, we seem to have in lichens the highest expression, so far as it is known, of mutualism. The alga does not reproduce in the association, except by fission, but it is protected in such a manner that it can grow where it could not otherwise, and its continued existence, or the succession of individuals rather, is assured. And though the fungal symbiont produces various reproductive bodies, it may well be doubted whether any reproduction other than vegetative often takes place in lichens in a state of nature. Again, it is evident from observation, that many new species of lichens have been evolved from closely related species. Thus the lichen, after all, in many ways appears much like a morphological unit, and J. Reinke has arrived at the conclusion that it must be so regarded, and has succeeded in unsettling to some extent the idea that lichens should be regarded as fungi.

Some botanists still hold that the relationship of the fungus and the alga is antagonistic. Whatever may be the outcome of further study of this question, the conception brought out in the above historical review, which is still held by some botanists, that the fungus and the alga together compose an organism or an association which constitutes the lichen must be abandoned before there can be any clear thinking regarding lichens. The lichen is the fungus of the association. This is true even in the few instances in which the alga determines the form of the thallus.

Certain botanists regard it as a corollary of this conclusion that, from a strictly systematic point of view, lichens should be distributed as fungi and some workers have already taken this position;^a but there are still some lichenists and other botanists who would be pleased with no other statement than that lichens compose a distinct group of plants. In view of the lack of agreement among authorities and for strong practical reasons it is not held advisable to undertake the distribution of lichens as fungi in the present paper.

^aSee Bessey's "A Synopsis of Plant Phyla," University of Nebraska Studies 74: 1-99. 1907, and Clements's, "The Genera of Fungi," 1909, briefly reviewed in SCIENCE; n. ser. 30: 567, 568. Oct. 22, 1909.

DISPOSITION OF LICHENS ADOPTED IN THIS WORK.

It is here accepted as an established fact that lichens arose through associations of alga and fungus in a symbiotic relationship. Once a lichen was established, it began to vary, so that we now have abundant evidence that many genera and species of lichens belong to the same phylogenetic tree.

The vegetative tract is commonly much reduced in fungi as a result of parasitism or saprophytism, since the food is either prepared by the host plant or found ready made in the substratum. However, in the fungi which have entered into associations with algæ to form lichens, the vegetative tract or thallus has assumed the new function of protecting the algæ so that they can increase in number and perform more effectively their duty in the partnership. In response to this change in function, the highly varied and complex foliose and fruticose thall of the higher lichens have arisen, in their evolved forms departing widely from the most closely related fungal ancestors.

Add to this the peculiarities of reproduction among lichens, a problem still needing careful study, and we shall have some of the facts which cause many botanists to maintain that lichens, after all, constitute a distinct class of fungi, or perhaps two distinct classes. However, others hold that lichens should no longer be treated separately except for special purposes in much the same way as parasitic fungi or poisonous plants, not necessarily all closely related, are often grouped together. Further phylogenetic studies may lead to the distribution of lichens among fungi, to the exclusion of the class Lichenes. This method would then be used in the general systematic treatment of fungi, though there would still remain students who would treat lichens separately. The present work is the result of many years of study of the lichen flora of a particular region, and therefore a separate treatment is the only method available. Taking into account, then, the unsettled state of opinion regarding the classification of lichens and the purpose of the present treatise, it seems best to follow Engler and Prantl in recognizing the class Lichenes.

THE FUNGAL SYMBIONTS AND THEIR RELATED FUNGI.

In all of the common lichens of temperate regions the fungal symbionts are Ascomycetes. The fungus has become so modified, in many instances, since entering into the symbiotic relationship, that there is little resemblance between it and the ancestral form. There is sufficient likeness, however, to lead to a general conviction that the fungal symbionts have been evolved in part from the Discomycetes and in part from the Pyrenomycetes. Of these two groups such genera as *Peziza*, *Patellaria*, *Hysterographium*, *Melaspilea*, *Phacidium*,

Chaetomium, and Sordaria are among those which may be closely related to the ancestors of the fungal symbionts. Further statements concerning the fungal ancestry will be found in the outline of classification.^a

THE ALGAL SYMBIONTS AND THEIR RELATED ALGÆ.

The algal symbionts are much better understood than the fungal. Indeed, in the descriptions of genera in this volume statements are made regarding the algæ to be found in each genus, and some use is made of these algal types in classification into families and genera.

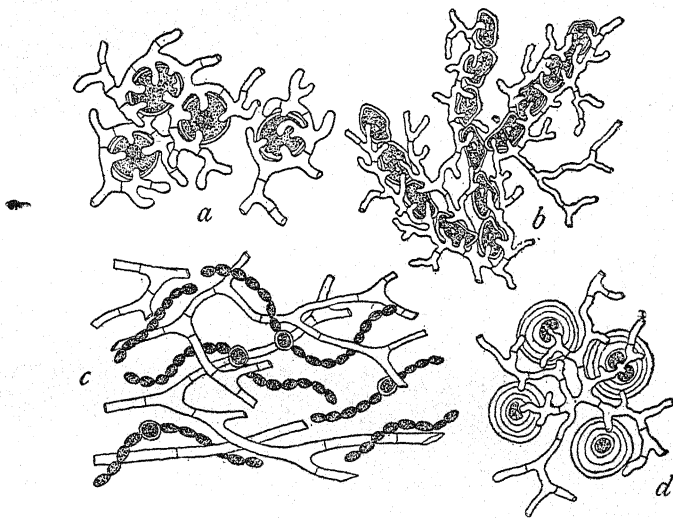


FIG. 1.—Algal types with associated fungal hyphae. *a*, Cystococcus, each cell surrounded by haustoria. *b*, Chroolepus, showing a branching chain of cells, surrounded by haustorial hyphae. *c*, Nostoc, showing the algal filaments and the intermingled fungal hyphae. *d*, Gloeocapsa, showing the haustoria and the fungal hyphae surrounding the algal cells. *a*, Enlarged 750 diameters; *b*, 325 diameters; *c*, 500 diameters; *d*, 650 diameters. From Schneider.

The alga most commonly found in lichen thalli is of the genus *Cystococcus* (fig. 1, *a*), and this genus is closely related to *Pleurococcus* (fig. 2, *d*, p. 10), which itself is supposed to be the algal symbiont of a few common lichens. Sections of lichens of the genera *Collema*, *Synechoblastus*, *Leptogium*, and some others show chains of cells which are so similar to those of free-living species of the algal genus *Nostoc* that we may regard these algal symbionts as certainly belonging to that genus. *Chroolepus* (fig. 1, *b*), an alga which may readily be distinguished from *Pleurococcus*, is the algal symbiont in a considerable portion of the crustose lichens. Other algal symbionts, which will be referred to only rarely in these pages, are *Gloeocapsa*

^aPage 37.

(fig. 1, *d*, p. 9), Rivularia (fig. 2, *a*), Polycoccus (fig. 2, *b*), Dactylococcus (fig. 2, *c*), and Sirosiphon (fig. 2, *e*).

GROSS MORPHOLOGY.

Under this head we shall consider only those lichen structures which may be seen readily with the unaided eye or with an ordinary hand lens.

THE THALLUS.

The fundamental part of a lichen is its vegetative tract or thallus. The thallus may be an erect structure, rising from the substratum, a pendulous one hanging downward from it, a conspicuous or inconspicuous flat one closely or loosely attached to the substratum, or

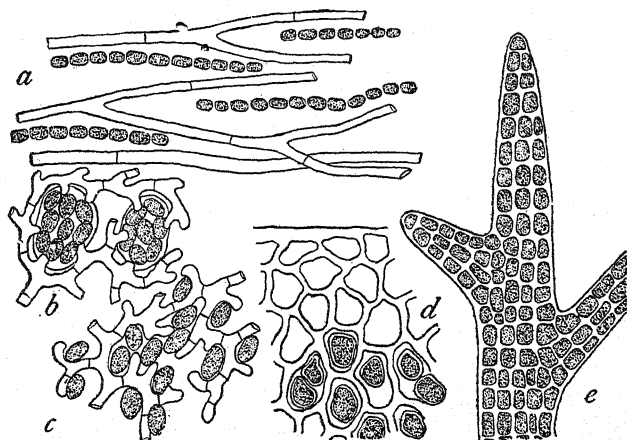


FIG. 2.—Algal types with associated fungal hyphae. *a*, Rivularia with the fungal hyphae intermingled. *b*, Polycoccus: colonies of cells surrounded by hyphae and haustoria. *c*, Dactylococcus: elliptical algal cells and fungal hyphae. *d*, Pleurococcus, the irregular algal cells inclosed in fungal hyphae. *e*, Sirosiphon, a terminal branch not showing the fungal hyphae. *a*, Much enlarged; *b*, *c*, enlarged 325 diameters; *d*, 450 diameters; *e*, 250 diameters. From Schneider.

an inconspicuous one largely or even wholly embedded in the substratum. Erect and pendulous forms are commonly called fruticose thalli (pl. 43, A, facing p. 210), and the flat or horizontal ones may be either foliose (pl. 28, facing p. 157) or crustose (pl. 8, B, facing p. 100); foliose when somewhat leaf-like and crustose when forming a closely attached crust resting on or within the substratum. Various intermediate conditions between crustose and foliose and between foliose and fruticose types of thalli may be expected in the study of lichen species.

GENERAL FORMS OF THALLI.

Of the foliose forms, many are variously lobed (pl. 30, facing p. 160) and some are quite entire at the margin. In instances where the lobing is evident the lobes may be more or less imbricated. In both lobed and unlobed forms the margin may be wavy or crenate instead of

entire, and it may be either ciliate or devoid of cilia. The most obtrusive differences among the fruticose thalli consist in their being branched or unbranched and, when the former, in the manner of their branching. Secondary differences are found in the character of the surface, particularly in various small outgrowths other than the branches, known as phyllocladia. The crustose thalli appear usually as a more or less conspicuous layer spread over the substratum or sometimes really lying wholly or partly in it and indicated at the surface often only by a change in color. These crustose thalli will be found to be irregular in outline or more or less plainly orbicular and to form a continuous or a more or less broken and scattered stratum (pl. 8, A, facing p. 100). In some species the tendency is toward orbicular forms and in others toward irregularity in form, but in any case the peculiarities of the surface of bark, dead wood, or rock forming the substratum will determine the form of the particular thallus to a large extent.

Lichens are of late evolution, and the forms are still quite plastic. Nevertheless, the forms, sizes, and colors of lichen species are quite as constant as those of many other organisms, whether plant or animal. Indeed, in many lichens the morphological characters, whether gross or minute, are quite as constant as are those of most flowering plants, and it may well be doubted whether even the *Cladonias* are more plastic than the members of the genus *Crataegus*, including our common hawthorns.

SIZES OF THALLI.

In northern Minnesota the fruticose thalli (pl. 42, B, facing p. 206) of *Usnea longissima*, which grows in tangled masses hanging over the branches of trees, frequently reach 1.5 meters in length, while the foliose thalli of *Gyrophora dillenii*, in the same portion of the State, sometimes reach 35 cm. in their longer diameter. Both fruticose and foliose thalli may vary from these large forms to minute ones not more than 0.2 mm. in height or diameter. In the crustose thalli the spread over or within the substratum may vary greatly, but is seldom more than 10 cm. In these and the foliose forms the thickness is to be taken into account. In the descriptions, however, actual measurements of thickness are very seldom given, though comparative statements are often resorted to. In the descriptions of the fruticose forms the diameters of the thalli or of their branches are usually given; and here again a considerable amount of variation is found, though very much less than in length.

SURFACES OF THALLI.

In the foliose thalli the upper surface is comparatively smooth, wrinkled, corrugated, or pustulate, and it may bear cilia, soredia,

or the minute growths known as isidioid branchlets. The margin of the thallus may be closely attached to the substratum (pl. 36, A, facing p. 194), or more or less ascending (pl. 30, facing p. 160). The lower surface is more or less covered with the attaching organs known as rhizoids. These may be large or small, numerous or few, and evenly scattered or collected into rows or into groups of different forms. The lower surface is sometimes quite smooth except for these rhizoids, but in other instances it is variously wrinkled or pitted, or in *Gyrophora*, provided with vertical plates which give strength.

In the fruticose thalli the surface is either smooth or more or less pitted, and in some instances it is somewhat tomentose. The *Cladonias* put forth as superficial outgrowths the flat expansions known as squamules. The *Stereocaulons* bear the peculiar structures more irregular in form called phyllocladia. The form, size, frequency of occurrence, and distribution of these organs must be noted carefully. In the *Cladonias*, especially, it is necessary to observe whether the cortex of the podetium is entire or more or less broken, so that it becomes areolate or even disappears over some portion of the organ. In this same genus observation with a lens is necessary to ascertain whether any part of the fruticose portion of the thallus is sorediate or not.

Finally, turning to the crustose thalli, they are also smooth or variously roughened. Those that are hypophlœodal or hypolithic simply take the contour of the surface of the substratum, as do also some thin and smooth forms that are in part or wholly epiphlœodal or epilithic. Others are scurfy or granular, and these are usually rather poorly developed and thin. In thicker forms is found the warty or verrucose condition; sometimes there occur here and there minute chinks, so that the thallus is said to be rimose or chinky; or finally the chinks may become numerous and divide the thallus into minute or small several-sided areas, known as areoles (pl. 8, B, facing p. 100), in which case the thallus is said to be areolate.

COLORS OF THALLI.

As compared with size and form, color is usually regarded as a rather more variable and therefore less reliable taxonomic character. Yet the colors of thalli play an important part in determining lichens and, though often quite variable, they must be carefully noted. Colors in lichen thalli vary all the way from a white to a black, but the most common is a greenish gray, in this paper designated as sea green. Some other colors which occur are ashy, olivaceous, brown, and straw color, together with various intermediate shades, as brownish black, olive brown, etc. The thallus, further, is often more or less variegated, while the lower surface is frequently of a different color from the upper. Also, in the fruticose forms the basal portion is frequently of a different color from the distal portions, usually darker.

The tendency of thalli, as of other lichen structures, is to darken with age, and the variations of color in a species may usually be traced to peculiar conditions of growth.

THE APOTHECIUM.

Likewise in the fruit, or apothecium, the main features of gross morphology are size, form, and color. The apothecia are usually superficial and large enough to be seen easily with the unaided eye (pl. 8, A, facing p. 100). In some instances, however, they are so small that they can be made out only with difficulty with the hand lens; or they may be immersed in the thallus and indicated at the surface by a slight elevation or depression as a disk or an ostiole (pl. 49, A, facing p. 235); or, when immersed, they may be scarcely discernible in any way except in sections of the thallus. From 0.1 to 5 mm. is well within the range for diameters of apothecia.

The apothecia are most commonly saucer-shaped, or some slight modification of this form, as when the disk is flat or somewhat convex instead of concave. In some instances the disk becomes very concave, the apothecium at last becoming cup-shaped. In other cases it is strongly convex, giving the apothecium at maturity a spheroidal form. In all of these forms the outline of a transverse section of the apothecium when young would usually be very nearly a perfect circle; but the form may become irregular as growth proceeds, so that at maturity this outline is quite irregular. In other lichens the apothecia are of some other form from the beginning. Thus, there are the elongated and often branched forms, such as are found in *Graphis* (pl. 2, A, facing p. 54), and the difform or variously irregular forms, as in *Arthonia* (pl. 2, B). Again, some apothecia are produced into a well-developed *perithecium*, and these usually approximate a spherical form.

THE DISK.

In those lichens in which the exciple (see below) is not produced into a perithecium the upper surface of the apothecium is naked, except for a very thin film of thallus which may persist as an *epithecium*, a structure not mentioned in the descriptions of species. This upper and essentially naked surface, whether flat or more or less strongly concave or convex, forms the disk. The outline of the disk, then, may be circular or variously elongated or irregular, varying in this respect with the form of the apothecium as a whole. In color the disk varies considerably even in the same species. It is usually light-colored in its early development and commonly becomes darker as it reaches maturity. The final color may be a light or darker flesh color or a light or darker shade of yellow, orange, red, brown, chestnut, olive, or even black. Whatever the color, it is very seldom

the same as that of the thallus. The surface of the disk, further, may be pruinose, usually with a white powder, concealing the essential color.

THE EXCIPLE.

Below the disk is the *hymenium* (pl. 3, fig. 3, *a*, facing p. 63), which may easily be seen in sections with the hand lens. This structure is usually lighter in color than the disk and is composed of paraphyses and asci. (See under minute morphology.) Below the hymenium is the *hypothecium* (pl. 3, fig. 3, *b*, facing p. 63), often darker in color than the hymenium above it, so that the line of demarcation between the two structures may easily be made out with the hand lens. The hymenium and hypothecium are mentioned here mainly that another structure, the exciple, may be located with reference to them. The exciple is a saucer-shaped or cup-shaped rim around the hymenium, consisting primarily of a continuation of the hypothecium upward on all sides. Such is the *proper exciple* (fig. 8, *b*, p. 60); but there is sometimes outside of this, or more often replacing it, what is known as a *thalloid exciple* (fig. 16, p. 232). This is similar to the thallus in structure, and usually of the same color, which is never true of the proper exciple, this usually approaching the disk in color. Either of the exciples may be entirely absent, and either or both may be quite evanescent and seen only in young apothecia; but usually one of them is present and either permanent or only tardily disappearing. It may be seen readily with the unaided eye or by the aid of the lens, and its nature and degree of development and permanence are points of considerable value in the classification of lichens, even to the determination of species. The perithecium, already mentioned, is simply a produced exciple found in some lichens, growing completely around the upper part of the hymenium but for the small opening or ostiole at the summit (fig. 17, p. 239). The margin of a proper exciple is usually about at the level of the outer margin of the disk, or it may be somewhat raised above the disk. This margin is almost always quite entire, while the margin of a thalloid exciple is frequently crenulate or crenate, or variously branched, ciliate, or irregular.

POSITION OF THE APOTHECIA.

Sometimes the apothecium is raised on a slender upward extension of the thallus, a short stalk or pedicel, quite different in form from the stipe and podetium soon to be described. This is most frequently met in the larger foliose lichens. The stalk may be absent and the apothecium attached to the thallus at the center of its lower side, in which case the apothecium is said to be *sessile*. Again, the apothecium may be more closely attached to the thallus by the whole of its lower side, when it is said to be *adnate*. Finally, the apothecium

may be more or less immersed in the thallus, sometimes deeply, so that when the disk is more or less overgrown by the thallus or by a perithecium the structures are often quite obscured. The development of the apothecium begins below the surface of the thallus, and the tendency in general is to become more and more superficial as maturity is reached. Sometimes, however, it remains permanently more or less immersed, and somewhat varying conditions as to position with reference to the thallus may be expected in many species.

STIPES AND PODETIA.

These are structures which serve to raise the apothecium into the air, and are both to be regarded as originally developed for this purpose. In such genera as *Calicium*, *Cyphelium*, and *Coniocybe* this is their only function, and where this is the case they receive the name of *stipes*. But in *Cladonia* and *Stereocaulon* the stipe takes up, in addition, the office of fostering algal cells and by its vertical extension and often ample branching greatly increases the area of surface behind which the algæ may find protection. In this case the structure is called a podetium, the proper stipe being devoid of algal cells. The stipe, therefore, belongs to the fruiting tract, while the podetium, doubtless modified from this, has the essential character of the thallus and more properly belongs to the vegetative tract.

RHIZOIDS AND CILIA.

The rhizoids are found on the ventral side of most foliose thalli and serve as attaching organs. They appear to the eye as root-like bodies, varying in color from white to black.

The cilia are like the rhizoids in structure, but are found on the upper surface of the thallus or along the margins. The hyphal rhizoids of the crustose lichens^a are quite different morphologically. The functions of cilia are doubtless to retain drops of water and gradually absorb them and sometimes, when quite numerous, to protect against cold or dust. Closely related to rhizoids is the single attaching organ known as the *umbilicus* on the ventral sides of the thalli of *Gyrophoras*, *Umbilicarias*, and many *Dermatocarpons*.

OTHER STRUCTURES.

Spermagonia, *soredia*, *cephalodia*, and *cyphellæ* are structures which occur on or near the surface of thalli. The *spermagonia* (fig. 3, p. 16) are the supposed male reproductive organs, sometimes quite conspicuous as dark-colored spots on the upper surface of the thallus, as in some *Parmelias* and other large foliose lichens; but these structures are more often minute and of the color of the thallus so that

^a See page 17.

they appear only in sections. They were formerly thought to be of considerable value in the determination of species. Their structure and functions will be further considered in the section on reproduction. The soredia are small, powdery masses, usually whitish in color, and scattered over the surface of the thallus as in *Pyxine sorediata* (pl. 48, facing p. 230) and many other lichens. They will be further considered in succeeding sections. Cephalodia are wart-like bodies found on the upper surface of the thallus as in *Peltigera aphthosa* (pl. 30, facing p. 160), or within the thallus, as in some other lichens. Cyphellæ are small pits or depressions in the lower surface of some foliose thalli as in some *Stictas* (pl. 26, facing p. 154). Cephalodia and Cyphellæ will be further considered under minute morphology, as their structure can be made out only with the microscope.

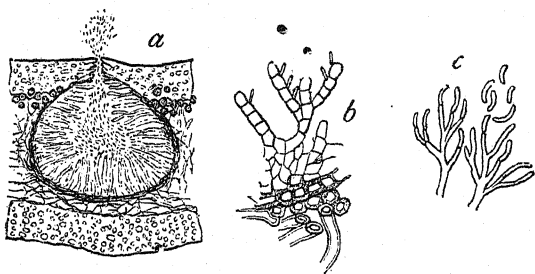


FIG. 3.—*Gyrophora cylindrica*. a, Median section through a spermatogonium; b, sterigmata and spermatia; c, sterigmata and spermatia of a *Cladonia*. a, Enlarged 90 diameters; b, 390 diameters; c, 450 diameters. a and b from DeBary; c from Tulasne.

Finally, in some lichens the so-called *hypothallus* is conspicuous to the unaided eye or seen with the lens. This is true of some members of the genus *Pannaria*. For instance, in *Pannaria nigra* this structure appears as a bluish black ring all around the thallus. Its nature is not well understood, but possibly it is a remnant of some lichen that the *Pannaria* has overgrown. Some of the older authors considered the rhizoids a portion of the hypothallus. In the present work there has seldom been occasion to refer to this little-understood structure.

MINUTE MORPHOLOGY.

FOLIOSE THALLI.

In the foliose type of thallus there are the following layers: An upper dermis, an upper cellular cortex, an algal layer,^a a medullary layer, and a lower cellular cortex (fig. 4, p. 17). The dermis, however, is scarcely distinguishable in many foliose lichens, and there are several other variations from the structure just outlined. For instance, in *Collema* (pl. 21, facing p. 136) there is no cortex, and the algæ are not arranged in a definite layer; in some of the *Physcias* the cellular cortex is replaced by layers of densely interwoven hyphæ; in *Peltigera* the upper cellular cortex is present, but there is none below; a few small foliose thalli, as in some *Acarosporas* (pl. 32,

^a The algæ, however, are not strictly a part of the thallus but are inclosed within it.

facing p. 170), are cellular throughout. Other instances of similar modifications in structure will be met in the descriptions of the genera of Minnesota lichens.

CRUSTOSE THALLI.

In those crustose forms that are hypophlœodal or hypolithic, there is simply a tangled layer of interwoven algal cells and fungal hyphæ, without any differentiation into layers. In the epiphlœodal and epilithic species the structure may be quite as rudimentary, or there may be a more or less evident upper pseudocortex of interwoven hyphæ (pl. 4, fig. 4, *a*, facing p. 67). In instances of the latter kind there is frequently also a more or less distinct algal layer below the pseudocortex (pl. 4, fig. 4, *b*) and some representation of a medulla below the algal layer (pl. 4, fig. 4, *c*). Whether these superficial forms are thus differentiated or not, the modified hyphæ known as hyphal rhizoids may always be looked for penetrating the substratum. It is, however, very difficult to obtain them in sections of these thalli. With each description of a crustose genus will be found a statement regarding the amount of differentiation.

FRUTICOSE THALLI.

The fruticose type of lichen thallus is peculiar, and is for this reason treated after the crustose type. Fruticose thalli are usually, though as noted below not always, more or less cylindrical in form. The outer layer of the cylinder or other form is a pseudocortex of densely interwoven hyphæ, extending either in the direction of the axis or at right angles to it. Within this outer layer is the algal layer, which, like the outer layer of hyphæ, is commonly more or less nearly circular in transverse section (pl. 11, fig. 4, *a*, *b*, facing p. 107). Sometimes, as in *Alectoria*, there is within the algal layer a well-developed medullary layer filling the remainder of the space and making the cylinder a solid one. In other instances the medulla is poorly or scarcely at all developed. Within it, when only par-

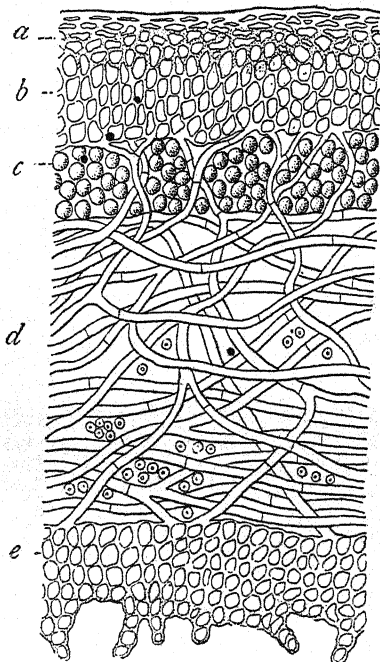


FIG. 4.—*Sticta amplissima*, section of the thallus. *a*, The dermis; *b*, the upper cortex; *c*, the algal layer; *d*, the medullary layer; *e*, the lower cortex. Enlarged 400 diameters. From Schneider.

tially developed or within the algal layer when the medulla is wanting, is frequently found a solid or a hollow cylinder of hyphæ extending in a longitudinal direction (pl. 18, fig. 3, *b, c*, facing p. 131). If this cylinder is hollow there are usually strengthening bundles of hyphæ to be found traversing the hollow central portion of the thallus in the transverse direction.

The outer pseudocortex is usually composed of hyphæ that are more or less gelatinized, so that the structure is very difficult to make out (pl. 11, fig. 4, *a*, facing p. 107). This gelatinization no doubt increases the protective function of the pseudocortex. The inner cylinder of hyphæ functions principally for conduction like a stele and the walls of the hyphæ show much less gelatinization. The algal layer is seldom a complete cylinder, the algæ more often appearing in clusters incompletely filling the space. The pseudocortex is seldom even approximately of the same thickness throughout and is sometimes scarcely at all developed except over the algal clusters. This arrangement brings the algal layer into closer contact with the atmosphere without completely exposing the algæ. The hyphæ are much less frequently branched in fruticose thalli than in foliose or crustose forms. In connection with this fact it is to be noted that fruticose thalli are not always even approximately cylindrical in form. Of the Minnesota species, *Ramalina calicaris fraxinea* departs most widely from the cylindrical form and appears much more like a foliose thallus growing away from the substratum, to which it is attached at a single point. However, when we section this thallus the structure is seen to be essentially that of the fruticose type. Indeed, in outward form, there is every gradation between the fruticose and the foliose thallus, and in a few so-called fruticose thalli there is found the cellular cortex characteristic of a foliose thallus.

THE DERMIS.

This structure consists of a few layers of flattened cells, lying upon the cortex and derived from it. The dermis aids in protection against excessive evaporation of moisture, and from its surface there sometimes arises a dense covering of short hyphæ which also functions in the same way. These are the *trichomatic hyphæ* of certain *Peltigera*s, and they also serve in *Peltigera aphthosa* to help in retaining the soredia which develop into cephalodia. The dermis is rudimentary or wanting in most lichens except *Peltigera* and *Sticta* (fig. 4, *a*, p. 17). The inner layers of cells are less flattened and gradually pass into those of the cortex from which they are developed.

THE UPPER CORTEX.

This structure is cellular (pl. 9, fig. 4, *b*, facing p. 101), consisting usually of several layers. The cells of these layers may be as distinct

as those of any ordinary parenchyma or the walls may be gelatinized and swollen to such an extent that the cellular nature is not made out. This layer may appear quite hyaline in section or it may contain more or less of some coloring matter. In the majority of the foliose lichens such a structure is developed both above and below, and the lower cortex is more frequently of a dark color. However, as already stated, there are a number of foliose genera in which part or all of the species lack such a cortex on one or both sides. And it may be added here that in *Leptogium* (fig. 5) the cortex usually consists of a single layer of cells.

The cortex is constantly being built up from the hyphæ of the algal layer below and is gradually transformed above into a dermis. In this gradual upward passage of tissues dead algal cells become entangled and are at length carried off by the abrasion

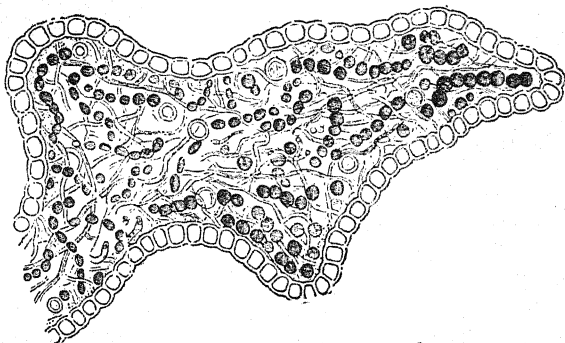


FIG. 5.—*Leptogium scotinum*, showing single layer of cells in the cortex and the intermingled fungal hyphæ and algal filaments within. Enlarged 550 diameters. From Sachs.

of the upper surface. The lower cortex is usually thinner and is more often absent than the upper; but in thalli in which this lower cortex is especially needed for mechanical support it is often better developed and thicker than the upper cortex.

THE ALGAL LAYER.

In some instances, as in *Collema* (fig. 1, c, p. 9), the fungal hyphæ are simply in contact with the algæ and in others they are attached to them by haustoria. In some cases the haustoria penetrate the walls of the algal cells and they are then said to be intracellular. These naturally secure the closest union. Every gradation between intracellular and extracellular haustoria may be looked for in certain species, but it is rarely the case that the haustorium attains a full development, i. e., is divided into a network of hyphæ, within the algal cells. Indeed, intracellular haustoria are either very rare or not often distinguished as such. The extracellular haustoria usually consist of a network of short, thin-walled hyphæ growing over a large portion of the outer surface of the wall of each algal cell. Where these are present the food must pass through the wall of the haustorium and also through that of the alga, but in instances where the haustoria become intracellular the passage is through the wall of

the haustorium only. The algal cells of the algal layer are numerous in vigorous thalli, but in old and dying thalli few of them occur in the living state. The hyphæ of this layer give rise to the outer or upper cortex, whether a true cortex or a pseudocortex, and are also continuous with the hyphæ of the medullary layer. The food assimilated by the living algæ, together with that which the fungus may be able to take from the substratum through the rhizoids, the umbilicus, or the hyphal rhizoids, serves both for the production of new algal cells by division and for the growth of various portions of the thallus. As the algal cells die and pass outward new ones are constantly being formed toward the lower or inner portions of the algal layer, so that the thallus is always possessed of an abundance of this assimilative tissue. The growth and division of the algal cells is of course most active in young and vigorous thalli and in the younger and more active portions of older thalli.

THE MEDULLARY LAYER.

The medullary layer lies below the algal layer in horizontal thalli (pl. 35, fig. 3, c, facing p. 191) and within it in fruticose thalli (pl. 11, fig. 4, c, facing p. 107). This layer consists of loosely interwoven fungal hyphæ and is especially adapted to give strength by connecting the layers above with those below or those without with those within. It serves also as a medium for the free passage of gases much after the manner of the spongy parenchyma of a leaf. The differentiation into algal layer and medullary layer is not always perfect even in the best developed thalli, and algal cells may occur in small numbers in the latter layer. The medulla is quite commonly the thickest of all the layers of the thallus, and the section in this portion of the thallus is more constantly transparent or hyaline than in either of the cortical layers. As the hyphæ of this layer serve for giving strength, the walls are scarcely ever perceptibly gelatinized. Aside from the functions already named, the hyphæ of the medulla must carry up to the algæ any materials taken in a crude state from the substratum by the attaching organs, whether rhizoids, an umbilicus, or hyphal rhizoids. Also the foods assimilated by the algæ must in part pass downward or inward by means of these hyphæ for the nourishment of certain portions of the thalli. It is also supposed that fats and other food materials are often stored in the hyphæ of the medulla.

THE LOWER CORTEX.

In most respects the lower cortex is very similar to the upper, but, as already stated, it is neither so constantly present nor is it as a rule so thick. When the lower cortex is present the rhizoids extend from it into the substratum, but when it is absent rhizoids are usually present as

continuations of certain hyphæ of the medullary layer. Plainly such a cellular tissue on the lower side of the thallus must serve for support, and it becomes very thick in those large foliose thalli which are attached by an umbilicus, as *Gyrophora*, *Umbilicaria*, and *Dermatocarpon*. But, since it lies between the rhizoids and the tissue above, this cortical tissue must permit the passage of any crude or elaborated materials taken from the substratum by the rhizoids, for which reason it remains thinner than might otherwise be expected. Also, the lower cortex is usually a looser tissue than the upper cortex and is usually darker colored. *Peltigera* is a genus of large foliose lichens in which there is a well-developed upper cortex and no lower cortex, while in *Collema* (pl. 21, facing p. 136) and *Synechoblastus*, genera containing large foliose forms, there is neither upper nor lower cortex.

SOREDIA AND SPERMAGONIA.

A soredium consists of a tangled mass of algal cells and fungal hyphæ which has pushed upward from the algal layer and appears at the surface in a small spot where the upper cortex is broken. The soredia function for reproduction. The spermagonia (fig. 3, a, p. 16) appear as little spherical or cup-shaped bodies, sunken in the surface of the thallus. Within each spermagonium are borne the *spermatia* on stalks called *sterigmata* (fig. 3, b). The spermatium is a small, slender body, commonly colorless, and straight or slightly curved (fig. 3, c). The spermatia are usually regarded as male reproductive bodies.

CEPHALODIA.

These bodies sometimes appear upon the surface of the thallus and in other instances occur within it. Those situated on the upper or lower surface are called *ectotrophic*, and those that are found within the thallus *endotrophic* cephalodia. There is much difference of opinion as to the frequency of the appearance of cephalodia, due partly to lack of careful observation and partly also to difference of view as to their nature. A cephalodium is an abnormal development upon or within the lichen thallus, containing some other algal symbiont than the one found in other portions of the thallus. The cephalodia of our *Peltigera aphthosa* (pl. 29, facing p. 159) are ectotrophic and plainly visible. The foreign algæ found in the cephalodia of this lichen are of the genus *Rivularia*, and they are supposed to be brought to the thallus in some way and, being held by the trichomatic hyphæ, to multiply and become surrounded by a true cortex. Ectotrophic cephalodia also occur in *Stereocaulons*, and the algæ contained are not always the same. But these are minute structures and seldom noticed. Endotrophic cephalodia are said to occur sometimes in *Sticta amplissima*.

CYPHELLE.

These structures are small pits found on the lower side of certain thalli. They are common in the majority of *Stictas* (pl. 26, facing p. 154). As lenticels commonly appear at points corresponding to the positions of stomata in seed plants, so the cyphellæ appear at points on the lower surface of the lichen thallus corresponding to the position of breathing pores. (See next section.) In their development a circular break first appears in the lower cortex, over the breathing pore. As the opening in the cortex increases in size, the adjacent hyphæ of the medullary layer give off numerous short branches, which fill the bottom of the opening so that the cyphella appears as a minute cup-shaped or saucer-shaped depression, whose bottom and sides are covered over with a dense coating of short hyphal branches. Indeed, in all of the Minnesota *Stictas* that contain cyphellæ these branches completely fill the cavity of the organ. The position of the cyphellæ over the breathing pores would seem to indicate that they serve to admit air to the interior of the thallus.

BREATHING PORES.

In lichens having a thallus well developed on both sides, it is evident that some provision for the admission of air to the interior will be advantageous. This is especially true where the cellular cortex is quite thick. The breathing pores of the lower cortex in *Stictas* have just been mentioned. Such structures are found in the lower cortex of many other lichens, but are even more common in the upper cellular cortex. They consist of more or less branched pores extending from the surface of the algal layer upward through the cortex in a somewhat irregular course and having no proper wall of their own but forming simply intercellular canals. They resemble stomata in that they can be closed, and also, as in the case of stomata, it is doubtful whether they are really of as much use for the exchange of gases as for some other purpose. They are found closed when the thallus becomes dry, and this doubtless helps to prevent the transpiration of moisture. Similar openings between the hyphæ of pseudocortices may sometimes be made out, especially when these cortices are quite thick. However, whether the cortex is cellular or not, these pores are to be looked for, for the most part, in the thinnest portions of the cortex, especially over areas where the algal cells are numerous.

GROWTH OF THALLI.

Since as a rule it is the fungus or the thallus proper which determines the form, the study of growth may naturally begin with this, though its growth is accompanied by an increase in the number of algal cells. In crustose and foliose lichens the growth is for the most part horizontal and mainly at or just behind the margin of the thallus.

The hyphæ in all portions of the thallus, however, may increase in length, either by the formation of new cells or by the elongation of old ones. In some instances the initial cells are equally active along the whole margin and the thallus is not lobed. But in some of the higher crustose species and the majority of the foliose species there are certain marginal areas where the initial cells are especially active, so that the horizontal growth is more active here than elsewhere. This uneven growth along the margin gives rise to the lobing so common in foliose lichens. Doubtless in the lower crustose lichens, where lobing is so uniformly absent, the frequent irregularity in form is due partly to irregularities in the surface of the substratum rendering growth more difficult at certain points than elsewhere, and in part also to loss of portions of epiphloeodal or epilithic thallus by abrasion. In all instances of lobing the form of the lobes is determined by the size and amount of activity of the areas of initial cells whose division forms the lobes. The thallus reaches its full thickness a short distance back of the growing margin. There is no further increase owing to the fact that, while new cells, both algal and fungal, are formed internally, abrasion of the general surface disposes of dead superficial cells to the same amount.

In most fruticose thalli the growth is mainly vertical instead of horizontal. There may be a single apical region, consisting of a continuous area of initial cells, and in such instances the thallus or the podetium will be unbranched. But in the great majority of instances there are areas of special activity, one corresponding to each branch of the thallus, whether horizontal, vertical, or lying at some intermediate angle. Here, as in all thalli, the manner of branching and the number of branches will depend upon the number and disposition of these areas of special activity.

But in some instances the growth of the thallus is essentially a growth of the algal instead of the fungal symbiont. This is the case in our *Ephebe pubescens* (pl. 24, facing p. 147), in which the alga branches dichotomously, has a single apical cell at the end of each branch, and determines both the growth and the form of the lichen.^a In *Collema* and *Synechoblastus*, where the algal cells are somewhat evenly distributed throughout the thallus, it is not very clear whether the algal or the fungal symbiont has more to do with determining the growth and form of the thallus. But since the growth is marginal and the irregular lobing seems to correspond to areas along the margin especially rich in algal filaments, it appears that the form is due mainly to the growth of the algæ. In the great majority of lichens, however, as already stated, the algal cells simply increase in number as the thallus increases in size. Thus the algæ always sustain a physiological

^a That is, according to the ordinary conception; but the real thallus is fungal and within the alga.

relation to the growth of the thallus and perform the function of assimilation for the fungal hyphæ.

THE APOTHECIUM IN GENERAL.

The fruit of a lichen is commonly called an apothecium, and consists of an epithecium, a hymenium, a hypothecium, and a thalloid or a proper exciple or both. Either or both of the exciples, however, may disappear, or the proper exciple may be produced into a structure known as a perithecium. Also, when a perithecium is present, it sometimes incloses an additional structure known as an amphithecium. These structures may now be explained in order.

THE EPITHECIUM.

This structure is supposed to be a film of the thallus extending over the upper surface of the apothecium, and its presence is explained by the fact that the development of the apothecium begins within the thallus and that the overlying part of this is carried up with the apothecium as it finally bursts through the upper cortex of the thallus. The epithecium is of the same color as the upper portion of the hymenium and is usually, when present, not distinguishable from it. Indeed, many of the older lichenists considered this portion of the hymenium a part of the epithecium and spoke of the epithecium as having certain colors, when the color was in the upper portion of the hymenium. In the descriptions to follow the epithecium has been ignored as something too rudimentary to be distinguished in an ordinary examination of a fruit, or, as probably in the large majority of instances, entirely absent in mature apothecia. Special statements are made, however, of the color of the upper portion of the hymenium when differing from that of the lower portion.

THE HYMENIUM.

The hymenium is composed of the asci or spore-containing sacs, and the protective filaments called paraphyses (fig. 9, *b*, p. 62). In position this structure lies below the epithecium and above the hypothecium. The asci are always thicker and usually shorter than the paraphyses, and the mature spores may usually be distinguished in them more or less plainly. It need be further stated here only that the asci and paraphyses usually are erect or suberect and constitute a densely packed mass composed of the two tissues.

THE THALLOID EXCIPIE.

This structure is commonly found in lichens having a well-developed thallus, whether fruticose or foliose, and is found, therefore, most commonly in the foliose lichens and least commonly in the crustose ones. In structure the thalloid exciple resembles the thallus (fig. 14, *b*, p. 178), with which it is always continuous. The outer layer of such

an exciple is directly continuous with the upper layer of the thallus, whether a true cellular cortex or a pseudocortex. This cortex of the exciple is often thicker than that of the thallus, to serve both for protection and support to the structures within and to aid in the dispersion of the spores. Within the cortex of the thalloid exciple there may be an algal layer and within this a medullary layer, but these two areas are by no means always clearly differentiated. There is no layer in any thalloid exciple that corresponds to the lower cortex found in so many foliose lichens. Occasionally the algæ may disappear from the thalloid exciple with age, but such a structure is still a thalloid exciple. The structure of the thalloid exciple is perfectly plain in instances where the apothecia are adnate, sessile, or pedicellate, but in instances where they are immersed it is by no means so easy to determine whether the portion of thallus surrounding should be regarded as a thalloid exciple. In some instances, also, where the thallus itself is of a rudimentary character and devoid of distinct differentiation into layers the thalloid exciple may be present in a similarly rudimentary condition, often simply as a thin veil, which may be quite evanescent.

THE PROPER EXCIPLE.

As the name indicates, the proper exciple is in reality a portion of the apothecium, being merely an upward extension of the hypothecium (fig. 11, *b*, p. 107) and, like it, either cellular in structure or composed of closely interwoven hyphæ. Both hyphal and cellular areas are found in a thalloid exciple, so that it is not always easy to distinguish between the two kinds of exciples by microscopic structure alone. The fundamental distinction is that if an exciple can be traced to the hypothecium (see below) it is to be regarded as a proper exciple, and if it can be traced to other portions of the thallus it is thalloid. But the thallus may be evanescent and disappear and a thalloid exciple still be present. In such instances the algal cells are usually present and the structure, further, does not appear to be continuous with the hypothecium. The hypothecium is always present, and the proper exciple may always be traced back to it in vertical sections through the center of the apothecium. Some authors seem to consider any exciple that does not contain algal cells a proper exciple, but such a disposition disregards morphological relationships and leads to confusion in the study of species. The proper exciple may be pale in section, or varying from this condition to a black color. It may be permanent or quite evanescent, and thin or very thick and conspicuous. It is a protective covering about the hymenium and is often produced into a perithecium, which completely surrounds the hymenium, except for the ostiole at the summit. The proper exciple also aids in the dispersion of spores.

THE HYPOTHECIUM.

This area lies immediately below the hymenium (fig. 9, *b*, p. 62) and varies considerably both in thickness and structure. Sometimes it exceeds the hymenium in thickness, but in most instances it is considerably thinner in vertical section. In structure it may be composed entirely of hyphæ (pl. 3, fig. 3, *b*, facing p. 63) or entirely of cells (pl. 11, fig. 3, *b*, facing p. 107) similar to those of a cellular cortex, or it may be partly cellular and partly hyphal. In some of the higher lichens, even when the structure is hyphal throughout, the hypothecium is more or less plainly differentiated into two layers, with the hyphæ extending in a general vertical direction in the upper layer and more nearly horizontally in the lower layer (pl. 40, fig. 3, *b, c*, facing p. 204). This differentiation may sometimes be made out in some of the lower lichens, and in some instances where the structure of the hypothecium is cellular throughout there is a similar differentiation into an upper and a lower layer. The cells and hyphæ of the hypothecium are smaller than the similar structures of the thallus, and the walls are more inclined to become gelatinized so that the structure is obscured; and the same statement applies to the proper exciple and the perithecium, which when present are continuations of the hypothecium. The color of the hypothecium, like that of the exciple, varies from the palest shades to black, and likewise the sections may appear perfectly hyaline. Both exciple and hypothecium often become darker with age, so that there may be a considerable amount of variation in color in the same species.

THE AMPHITHECIUM.

In those lichens in which the proper exciple is produced into a perithecium there is sometimes a dark layer outside and a lighter and often hyaline layer within between the dark outer covering and the hymenium. This inner layer is known as the amphithecium. In some pyrenocarpic lichens, in which the apothecia are immersed in the thallus, as in *Dermatocarpon* (fig. 18, p. 243), the dark, outer protective layer is not needed, and the whole of the tissue surrounding the hymenium is here hyaline or colorless, and this also is known as an amphithecium.

THE PARAPHYSES.

These structures are specialized hyphæ which arise from the tissues of the hypothecium. They are commonly cylindrical in form and divided by transverse walls into a number of cells. They appear at a hasty examination to be uniformly simple in most lichen species, but more careful observation usually brings to light some that are branched in nearly every hymenium. The branching may be

very limited (pl. 45, fig. 5, facing p. 217), or it may be extensive, as in most Arthonias. Careful statements as to the branching are made with the description of each species, but branching is so common and its character so difficult to trace that it may well be doubted whether the branching has any great diagnostic value. The paraphyses are usually distinct, but sometimes the walls are more or less gelatinized and the whole structure in some degree coherent and indistinct. They are usually longer than the asci, but are shorter than these in the case of the Verrucarias, in which they also become imperfectly or often wholly gelatinized. The tips, or apices, are usually thickened and darker in color than the remaining part. Other portions of the paraphysis may be somewhat colored; but usually the single organ appears quite hyaline, though the section of the hymenium often shows color. The functions are those of protecting the asci and the contained spores against too rapid transpiration and of aiding in the dispersion of the spores. The thickening and coloration of the apices aid in the protective function.

THE ASCI.

The asci arise, like the paraphyses (pl. 18, fig. 3, *a*, facing p. 131), from the tissues of the hypothecium, or also from special ascogenous hyphæ. They are usually shorter and wider than the paraphyses which surround them. In form they are most commonly clavate, but they may be cylindrical, pyriform, subglobose, or variously ventricose or otherwise irregular. The walls are usually more or less thickened toward the apex, probably by an accumulation of epiplasm (pl. 18, fig. 5, *a*, facing p. 131). The thickening may be very slight or it may occupy the upper third or more of the entire length of the ascus, as in some Arthonias. There is a succession of asci produced in each apothecium, and one may rarely find asci of two generations together, those of one generation containing mature or perhaps old and shriveled spores, and those of the other younger, larger, and unshriveled ones, perhaps also immature, as shown by color or condition of cell division. In Calicium and other closely related genera the upper portion of the wall of the ascus becomes gelatinized and dissolved before the spores are mature, and the spores escape and ripen in the hymenium outside the asci. In other ascomycetous lichens the spores mature within the asci, which then open at the apex for their escape. The apical wall may rupture irregularly, the end may become torn across in some regular way, or probably in many instances an apical plug is pushed out, as in some other ascomycetous fungi. However, there is lack of any extended observations as to the method of opening of the ascus in lichens.

THE SPORES.

These bodies are usually eight in each ascus and rather small in size, but the number may vary from one to many and the size is inversely proportional to number, varying from $3\ \mu$ to $200\ \mu$ or more in length. (See pls. 3, 4, 9, 11, 18, 21, 22, 24, 32, 35, 40, 46.) The most common forms are oblong or ellipsoid, but the spores vary from acicular to spherical. Usually the size and form are quite constant in a given species, but there are instances of considerable variation even in the same hymenium.

The spores as arranged in the ascus may be uniseriate, oblique, side by side, or more or less irregularly placed. They are likely to be side by side when acicular in form, uniseriate when spherical or oblong in a cylindrical ascus, and obliquely or irregularly arranged when the ascus is pyriform, thickly clavate, or ventricose-clavate.

The spores may be simple, two-celled, four-celled, or several-celled, the cells being, in most of the compound conditions, arranged in a single series, separated by transverse walls. Besides the transverse divisions, others may be formed in the direction of the long axis of the spore, giving what is known as a muriform spore. In the development of the muriform spore the transverse walls always appear first, and in some species of lichens usually only a portion of the spores are ever found in the muriform condition, though the others are probably to be regarded as immature. The polar two-celled spore is a peculiar form found in *Teloschistes* and *Placodium* in which the two cells are far apart, one at either end of the spore.

In color the spores vary from hyaline to a blackish brown. Simple spores are usually hyaline, but there are exceptions to the rule. Compound spores are very frequently more or less colored.

The spores are not always easily distinguished in the ascus, especially in rather thick sections. To bring them out better, the section may be carefully crushed on the slide, but one must always be sure that he sees the spores in the ascus, otherwise he may observe the spores of some other lichen and determine his specimen incorrectly. After making sure of the number of spores in each ascus and of their form and color, some may be studied outside of the ascus for the purpose of getting size, form, color, and structure more accurately. Minute spores may be mistaken in the ascus for the granular protoplasm of an immature ascus, and the acicular spores are also sometimes difficult to distinguish in the ascus.

THECIAL ALGÆ.

In some lichens there are found in the hymenium certain algal cells, commonly known as thecial or hymenial algæ. These algæ (fig. 6, p. 29) are usually smaller than those of the thallus, and are

perhaps of the same species, varying in size because of a difference in nutrition; but it is by no means certain that the thecial algæ are derived from the thallus of the lichen in which they occur. Among the Minnesota lichens they may be looked for especially in mature plants of *Dermatocarpon* and *Endocarpon*, though they may occur in some other closely related types. The algal cells are usually smaller than those of the thallus, and are often found clinging to the asci or to the paraphyses. By some it is supposed that they are dispersed with the spores and are at hand when the spores germinate, so that the symbiotic relation may be established at once and a thallus readily built up, provided other conditions are favorable. However, it may well be doubted whether reproduction often takes place in this way in nature, and it is much more probable that the main function of these algal cells is to nourish the fungal tissues within the apothecium. The fact that thecial algæ are more common in immature than in mature apothecia would favor this view. They are found in many immature apothecia of other lichen genera, but seldom persist. Doubtless these nonpersisting thecial algæ at least are foreign organisms which, having gained access to the young apothecia, endure for a time under more or less unfavorable conditions.

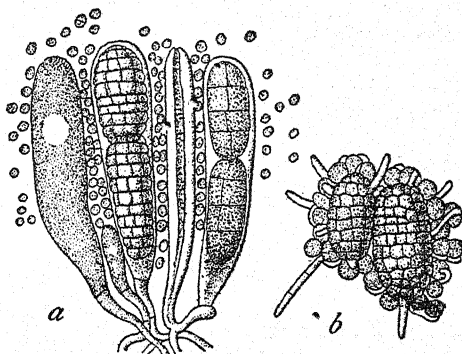


FIG. 6.—*Endocarpon pusillum*. a, The hymenial algæ intermingled with the asci and the paraphyses; b, two germinating spores surrounded by hymenial algæ. Enlarged 320 diameters. From Stahl.

DEVELOPMENT OF THE APOTHECIA.

This subject has been studied by various observers in Europe and America, and the origin and development seems to be very similar to that in the Ascomycetes in general. The first thing to be observed in the development of an apothecium is a mass of closely interwoven hyphæ below the algal zone, in the medullary area—this, of course, in those lichens in which there is a distinct differentiation into thallus layers. In *Collema* and some related forms, this differentiation is wanting, but the development here also begins within the thallus. The crustose lichens, which are without the layers, have not been carefully studied as to apothecial development.

The mass of hyphæ constitutes the beginning of the development of the hypothecium, and the structure increases rapidly in size, spreading out laterally and also increasing in thickness. From the

hyphæ of this young hypothecium arise vertical hyphæ, which soon become differentiated into paraphyses and asci, appearing first over the central portions of the mass of hyphæ and extending laterally in all directions as the hypothecium spreads out by lateral growth. The paraphyses and the asci are very similar in their early development, but the hyphæ which produce the asci very soon begin to enlarge so that the asci may be distinguished from the paraphyses while still very small. Also these asci-producing hyphæ always remain one-celled and are much richer in protoplasm than the others. Observers have thought that the asci and paraphyses arise from different systems of hyphæ and have called the supposed asci-producing elements ascogenous hyphæ, regarding them as arising from ascogonia. But more recently Sturgis, in this country, has arrived at the conclusion that both asci and paraphyses arise from the same system of hyphæ. More investigation is needed at this point. As the development proceeds the hypothecium is produced into the exciple or the perithecium, as the case may be.

Beginning its development within the thallus, the apothecium may remain immersed or it may become more or less superficial, being supported in the ways already described. As the apothecium pushes upward the surrounding thallus may or not grow up about it to form the thalloid exciple, and now, if at all, is formed the epithecium.

REPRODUCTION.

SOREDIA.

Among the means of reproduction in lichens soredia play an important part. These masses of fungal hyphæ and algæ may in proper environment produce a lichen thallus. They occur on many foliose and fruticose lichens and on some crustose species. A whole soredium or a portion of one is easily carried by the wind, and resting on a favorable substratum may develop into a lichen thallus having the same structure and bearing the same kind of apothecia, soredia, spermagonia, etc., as that on which the soredium developed.

There is no differentiation into layers in the soredium, nor is dorsiventrality established until after it begins to grow on the substratum. As growth begins, the hyphal rhizoids penetrate the substratum to secure nourishment and to anchor the minute mass of tissue. As growth proceeds, the fungal portion of the soredium usually becomes differentiated into cortex and medulla, and the algæ come to occupy their proper place in the thallus.

Soredia may develop on the thallus on which they are produced, into the isidioid branchlets frequently found on the thalli of some of the foliose lichens. Doubtless the reproduction by soredia is the most important method in many lichens. Indeed, a considerable

portion of the foliose lichens and a few fruticose and crustose ones seldom produce apothecia and spores.

FRAGMENTATION.

Another method of vegetative reproduction among lichens is by fragments of thalli becoming detached and blowing away and growing upon a suitable substratum. It does not matter how small the fragment provided it contains both the algæ and the fungal hyphæ. There may be all the layers of the thallus represented in the fragment or not. Sometimes the fragment is an isidioid branchlet and in other instances it is a large and conspicuous portion of the thallus. The latter condition is well illustrated in *Usnea longissima*, long masses of which are often seen in northern Minnesota hanging over branches, without any attachment whatever. In foliose and crustose lichens also the fragments may be large, and even whole thalli may be torn loose by the wind and transported to a new substratum and there grow.

REJUVENESCENCE.

In a considerable number of lichens the older portions of the thallus die while the younger portions continue to grow. This condition is quite common among *Cladonias*, where the basal portions of the podetia die and the branching above continues. The branches thus become separated and a number of individuals arise from one. Usually such an assemblage forms a dense cluster, but the central and more raised portion of the cluster frequently dies or is blown away, leaving a continuous or more or less broken ring of plants. In foliose and crustose lichens the central portion of the thallus often dies and the outer portions form a "fairy ring." The ring often becomes discontinuous, and thus a number of individuals arise from one. The dying at the center may be due to age or to the exhaustion of food substances from the substratum. *Lecanora muralis* and *Lecidea speirea* are species of crustose lichens in which this method of reproduction is often seen (pl. 33, facing p. 175).

SPORES.

The spores of lichens have repeatedly been proved to be capable of germination in cultures and of producing the usual forms of thalli of their species, both when sown with the algæ and when sown without them in favorable nutrient media. But the question still remains whether lichens are often produced from spores in nature. Evidently, except in the instances of germination in certain culture media, the spores of lichens must happen to come into contact with the alga of the same species as the one that forms the algal symbiont in the species of lichen by which the spore was produced. And, in addition, the conditions, substratic and other, must be sufficiently

favorable for germination and the production of a new lichen individual. It may well be doubted whether such a combination is likely to come about often enough that among lichens spores may be regarded as important agents in reproduction. The chances of reproduction by spores were plainly decreased greatly when the symbiotic relationship was taken on, and the result has in all probability been a considerable physiological degeneration of the spores in the course of phylogenetic development.

SEXUAL REPRODUCTION.

The sexual processes have not been studied in very many of the fungi most closely related to the lichens, but recent discoveries seem to indicate that sexuality is common there and in the ascomycetous lichens as well. In Collema, Stahl and others have found that the

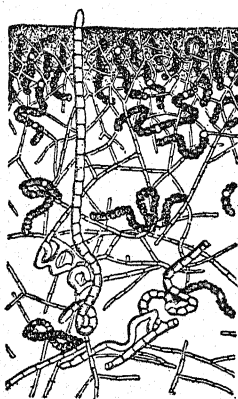


FIG. 7.—*Collema microphyllum*, showing the archicarp and the trichogyne. Enlarged 300 diameters. From Stahl.

apothecium is preceded by an archicarp and a triehogyne (fig. 7), which are supposed to constitute a reproductive tract. The more recent researches of Baur, Darbishire, Lindau, and Wainio have proved the existence of similar tracts in lichens of several genera, and while there is yet much need of research regarding nuclear behavior, the general presence of sexual organs in lichens can scarcely be questioned longer.

The spermatogonia have been supposed to constitute the male reproductive organs of lichens, and Stahl thinks that he has established beyond reasonable doubt that fertilization actually takes place, the spermatia (fig. 3, c, p. 16) from the spermatogones (fig. 3, a) becoming attached to the apex of the trichogyne, where a transfer of protoplasm occurs. Strangely enough, Möller, experimenting on lichens not closely related to *Collema*, has produced from the spermatia thalli in all respects similar to those which he obtained from spores. This would seem to indicate that the spermatia, if they are sexual cells, have become so degenerate in certain lichens as to lose their sexual function, becoming capable at the same time of reproducing vegetatively. However, it is supposable that the spermatia may not be degenerate but capable either of functioning for sexual reproduction or of developing parthenogenetically. It seems necessary to add that some botanists regard the spermatogones as bodies belonging to fungi parasitic on the lichen thalli.

The question of the sexuality of lichens, together with that of the origin and development of the apothecium, has in the last half century excited quite as much interest as the one regarding the nature

of lichens, and one quite as much as the other is in need of further elucidation.

ECONOMIC RÔLE OF LICHENS.

Lichens are among the most widely distributed of plants, and the traveler will find them wherever he may go. To the far north the species seem to decrease somewhat in number, but in the arctic and subarctic regions some of the plants reach considerable size and serve for food, both for man and for lower animals. Lichens are common in tropical regions also; but here they have not been so frequently resorted to for food. These plants have been used in the arts and for medicine, and they also play an important rôle in nature as purifiers of the air and in the reduction of rocks to soil.

AS PURIFIERS OF THE AIR.

Lichens take large amounts of carbon dioxide from the air, in the process of nutrition build up lichenin, a carbon compound very similar to starch, and return to the atmosphere as free oxygen the portion not needed in the production of lichenin and other compounds within the plants. It was formerly supposed that the lichens took a very small portion, if any, of their food from the substratum, but that view is certainly incorrect, at least in the case of many species. However, it is quite likely that most lichens take a smaller part of their food from the substratum and a larger part from the air than do the higher chlorophyll-bearing plants. But it is certain that the fungus forming the lichen takes more or less of crude or elaborated food materials from the substratum, while the algal cells of the partnership do the work of building up the lichenin. Thus lichens, in the ordinary processes of nutrition, aid in purifying the air by extracting carbon dioxide and giving back to the air a portion of the oxygen in the free condition. Lichens are very sensitive to conditions of the atmosphere and are becoming scarce near our cities and larger towns. This is due partly to the disturbance of substrata, but it is also true that the dust and the impurities of the air about cities are in some way unfavorable to the lichens. Doubtless the dust fills the pores of the thallus and interferes with the passage of gases, while some impurities interfere with nutrition and respiration. It is not the intention to give the impression that lichens are the great conservators of atmospheric purity, but rather that they contribute their share of work toward this end.

AS AIDS IN ROCK DISINTEGRATION.

It is well known that certain crustose lichens are the first plants to attack rocks and that they aid greatly in the reduction of rocks

to soil. It would seem from superficial observation that some lichens begin to grow on perfectly firm rock and, gaining a foothold, reach their full size and produce fruit while the rock is still in a firm and wholly undisintegrated condition. For instance, on the very hard Sioux quartzite in southern Minnesota the lichens are growing on perfectly smooth surfaces supposed to have been polished by the wind near the close of glacial times. Yet this rock shows to the eye or lens no evidence of disintegration and is, macroscopically, in exactly the same condition under the lichens as elsewhere. But in spite of this it is not supposed that the rhizoids of the lichens ever penetrate perfectly firm rock, but rather that the plant gains a point of attachment, perhaps in microscopic openings, and then begins to secrete an acid which slowly disintegrates the rock, the rhizoids penetrating deeper and deeper as the work of the acid makes a way for them.

In other portions of Minnesota may be found crustose lichens growing on rocks that have not yet fallen to fragments but are so rotten for several inches below the surface that they can easily be powdered by the foot. The work of rock disintegration is aided in its early stages by the lichens, and especially by the crustose forms. As the rock at the surface is gradually reduced to small fragments and soil the crustose lichens decay and add their quota of humus. On this bit of prepared earth, in some crevice or on a flat surface of rock, the foliose and fruticose lichens and certain mosses begin to appear and carry on the work begun by the crustose lichens. Then in turn appear ferns, herbaceous seed plants, and finally shrubs and trees, first in the crevices and at length over the whole surface, until the lichens are largely replaced by larger vegetation.

AS FOOD.

It is doubtful whether even the wild animals eat lichens to any considerable extent so far south as the pineries of northern Minnesota, for the reason that there is too much other available food. But it would not be surprising if some careful observations in winter would show that the moose, caribou, and deer eat the "reindeer moss," *Cladonia rangiferina* (pl. 12, facing p. 111), and other large *Cladonias* to some extent. Farther northward the reindeer moss and some other lichens are important as food for both man and lower animals. *Cladonia rangiferina* and two or three closely related species form the principal food of the reindeer and become in Lapland relatively as important as some of the grasses of our prairies. This happens for the reason that the larger plants do not drive out the lichens so effectually in regions to the north, so that the reindeer moss and some other lichens there cover large areas like the grasses in our

region. Some suggestion of this wonderful lichen growth may be seen in northern Minnesota, where patches may be found covering an acre or more of ground. Also in northern regions, both in America and Europe, other wild and domestic animals depend more or less upon these lichens for their food supply.

Lecanora esculenta grows loosely attached to the rocks in high places in northern Africa, is carried long distances by the wind, and, falling in areas where food is scarce, is eaten by the inhabitants, both man and lower animals. This plant is supposed to have been the manna of the children of Israel. Nor is this the only lichen eaten by man, for *Cetraria islandica*, the well-known "Iceland moss," forms an important part of the food of the people of Iceland, as well as of their domestic animals. This *Cetraria* is especially rich in the peculiar starch-like compound so commonly built up in lichen tissues. Also some of our *Gyrophoras* and other common lichens, as *Ramalina calicaris*, *Parmelia physodes*, *Peltigera canina*, and *Evernia prunastri* (pl. 39, facing p. 203), have been used as food by man.

The nutritive value of lichens is due mainly to the lichenin, or starch-like material. But there is a bitter substance found in the lichen which often gives an unpleasant taste and is irritating to the digestive tract. This may be removed by thorough washing in water or some alkali, after which the plants may usually be eaten with impunity.

When grains or potatoes are at hand, the lichens may be powdered and mixed with these articles of food and a very palatable bread may be made.

AS MEDICINAL AGENTS.

A considerable number of lichens have been used for medicinal purposes, but few of the supposed medicinal properties have been able to stand the test of modern medical science. Thus the "dog lichen," our common *Peltigera canina*, was formerly supposed to be curative of hydrophobia, hence the specific name. Likewise *Sticta pulmonaria* was supposed to cure pulmonary diseases, while the well-known *Usnea barbata* was supposed to promote the growth of hair and to be a sort of cure-all. *Evernia vulpina* is said to have been used, mixed with other substances, to poison wolves. Lindsay, in his Popular History of British Lichens, states that *Cetraria islandica* furnished preparations which were to be found in the drug stores of England at the date of publication of his volume, 1865, as curatives for dyspepsia, and we still find *Cetraria* given in our latest dispensaries as a remedy. It is the bitter principle of the lichens that is supposed to give them medicinal value, and it has been used in fevers, as a tonic, and as a purgative, as well as in the other ways mentioned above. Also, alcohol has been made from lichens.

AS DYESTUFFS.

Dyes of various colors have been extracted from lichens. The colors are usually reds, purples, or blues, and the dyes have been used for coloring cloth, wood, paper, etc. In Europe they have been quite largely employed in coloring homespun cloth and yarn, our common *Parmelia saxatilis* being ordinarily used, producing various colors according to the method employed in making the dye. In *Evernia vulpina* the yellow coloring matter is ready formed in the thallus, and the same may be said of the beautiful yellows and oranges of our *Teloschistes* and *Placodiums*. Brown colors are also ready formed in many lichen thalli, are easily extracted, and have been used for home consumption.

Most of these dyes are not to be had in sufficient quantities to be manufactured for the markets. However, *Roccella tinctoria*, a lichen found on our Pacific coast and on various coasts of the Old World, produces a pigment which has been known by one name or another since earliest historical times. "Orseille" is one of its names and "litmus" another. This is no doubt the "blue and purple" of the Old Testament, and in more recent times the same dye has been extensively used in France for coloring silks. At the present time paper is colored with a neutral solution of the dye and used commonly in chemical laboratories as litmus paper. Litmus is also found in the market as a carmine powder and as an indigo blue. In obtaining these lichen dyes, the thallus is pulverized and then some alkali is applied for the extraction of the coloring matter.

AS RELATED TO THE WELFARE OF TREES.

In France and other countries of Europe foresters have supposed that lichens are injurious to the trees and have to a limited extent practiced scraping the larger ones from the bark, along with certain other fungi. However, it would be difficult to accomplish much in this way in large forests, even were it known that the lichens are very injurious to the trees. In our country M. B. Waite, while experimenting with fungicides on fruit trees, noted that the Bordeaux mixture killed the lichens very effectually. He is not at all certain that the lichens are injurious to the trees, but thinks that they may at least interfere with the functions of the bark. It is true that the more conspicuous foliose lichens are more common on unhealthy trees than on thrifty ones (pl. 37, facing p. 195), but the question remains whether the lichens have worked the injury to the trees or whether unhealthy trees are more easily penetrated by the rhizoids of the lichens, and also whether they furnish some food materials for the lichens not present in healthy trees or not easily obtained from them. It is probably not worth while to take time to remove lichens from any trees of temperate regions for the sake of saving the trees from injury.

DESCRIPTIVE CATALOGUE.

OUTLINE OF CLASSIFICATION.

CLASS LICHENES.

ORDER ASCOLICHENES.

Lichens in which the spores are produced in asci. All of the Minnesota lichens belong here, except perhaps the last family below, in which the fungal symbiont may not be an ascomycete. The order Basidiolichenes includes but a few species and is confined to tropical regions.

SUBORDER CONIOPHOREAE.

The thallus is crustose, and the alga is *Cystococcus*, except perhaps in *Coniocybe*. The fungal symbionts belong to the *Protoceliaceae*. An erect and rarely branched structure, the stipe, arises from the substratum and bears the exciple and the hymenium. The stipes are devoid of algal cells and are to be regarded as parts of the apothecia rather than portions of the thallus. A proper exciple is present. The plants are minute and are difficult to detect; the stipes when best developed are only 0.2 to 2.5 mm. long.

FAMILY CALICIACEAE (p. 44.)

<i>Coniocybe</i> .	<i>Chaenotheca</i> .
<i>Calicium</i> .	<i>Acolium</i> .

SUBORDER GRAPHIDINEAE.

The thallus is crustose in all of ours, and the algal symbiont is *Chroolepus*, except in some *Arthonias*, where *Cystococcus* may occur instead. The fungal symbionts belong to the suborders *Stictidiaceae*, *Hysterineae*, and *Patellariaceae*. The apothecia are elongated and often branched, variously irregular, or rarely rounded. The fruticose *Roccelliaceae*, not represented in our flora, probably place the suborder as a whole above *Coniophoreae*.

FAMILY GRAPHIDACEAE (p. 52.)

<i>Opegrapha</i> .	<i>Arthonia</i> .
<i>Graphis</i> .	<i>Arthothelium</i> .

SUBORDER DISCOCARPINEAE.

The apothecia are commonly disk or cup-shaped, though a few forms show fruits nearly closed. The exciple is proper or thalloid or sometimes double when the thalloid exciple surrounds the proper exciple. The thallus varies greatly, showing crustose, foliose, and fruticose forms as well as various intermediate conditions. Likewise, all the forms of algal symbionts at all common in lichen thalli may be looked for in the suborder. The fungal symbionts are not easily traceable in most instances to their ancestral forms, but they belong, at least mainly, to the *Patellariaceae*. Nearly all of our conspicuous lichens belong to the present suborder.

FAMILY LECANACTIDACEAE (p. 59.)

<i>Melaspilea</i> .	<i>Lecanactis</i> .
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FAMILY GYALECTACEAE (p. 61.)

<i>Gyalecta</i> .	<i>Secoliga</i> .
<i>Conotrema</i> .	

FAMILY LECIDEACEAE (p. 64.)

Biatorella.	Bilimbia.
Lecidea.	Bacidia.
Megalospora.	Buellia.
Biatorina.	Rhizocarpon.

FAMILY PSORACEAE (p. 101.)

Psora.	Toninia.
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FAMILY BAEOMYCETACEAE (p. 105.)

Baeomyces.	Icmadophila.
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FAMILY CLADONIACEAE (p. 106.)

Cladonia.

FAMILY STEREOCAULACEAE (p. 129.)

Stereocaulon.	Pilophorus.
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FAMILY COLLEMACEAE (p. 132.)

Synechoblastus.	Collema.
	Leptogium.

FAMILY PYRENOPSISACEAE (p. 142.)

Pyrenopsis.	Omphalaria.
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FAMILY EPHEBACEAE (p. 146.)

Ephebe.

FAMILY PANNARIACEAE (p. 147.)

Endocarpiscum.	Heppia.
	Pannaria.

FAMILY STICTACEAE (p. 153.)

Sticta.

FAMILY PELTIGERACEAE (p. 157.)

Solorina.	Peltigera.
	Nephroma.

FAMILY GYROPHORACEAE (p. 166.)

Gyrophora.	Umbilicaria.
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FAMILY LECANORACEAE (p. 169.)

Acarospora.	Lecanora.
	Haematomma.

FAMILY PERTUSARIACEAE (p. 186.)

Pertusaria.

FAMILY PARMELIACEAE (p. 190.)

Parmelia.	Ramalina.
Cetraria.	Alectoria.
Evernia.	Usnea.

FAMILY TELOSCHISTACEAE (p. 211).

Placodium. Teloschistes.

FAMILY PHYSCIACEAE (p. 219).

Rinodina.	Pyxine.
Physcia.	Urceolaria.

SUBORDER PYRENOCARPINEAE.

The thallus varies from undifferentiated and mainly hypophloeodal or hypolithic crustose conditions to well developed foliose or fruticose forms. The algal symbiont is either *Chroolepus* or *Pleurococcus*. The fungal symbionts belong to the *Sphaeriaceae* or to closely related fungi. The apothecia are furnished with a perithecium, which entirely incloses the hymenium, except for the apical ostiole, and are more or less immersed in the thallus or the substratum. Within the perithecium is found the amphithecium, a less heavy layer. Or the perithecium may be almost entirely wanting, when the amphithecium alone is seen about the Hymenium.

FAMILY VERRUCARIACEAE (p. 232).

Verrucaria.

FAMILY PYRENULACEAE (p. 235).

Sagedia. Arthopyrenia.
Pyrenula.

FAMILY DERMATOCARPACEAE (p. 241).

Thelocarpon. Dermatocarpon.

FAMILY ENDOCARPACEAE (p. 244).

Endocarpon. Staurothele.

FAMILY LEPRARIACEAE (p. 247).

Amphiloma.

ARTIFICIAL KEY TO THE GENERA.

Thallus foliose (or squamulose).

Thallus of the modified foliose form known as squamulose.

Algal cells blue-green (probably Polycoccus); spores
hyaline or pale, simple to 4-celled..... PANNARIA (p. 150).

Algal cells bright green (Cystococcus).

Spores simple, hyaline, ellipsoid..... PSORA (p. 101).

Spores hyaline, ellipsoid, 4 to 8-celled..... TONINIA (p. 104).

Thallus plainly foliose.

Algal cells bright green (Cystococcus or Pleurococcus).

Spores simple, hyaline (sometimes slightly colored in *Gyrophora*).

Thallus attached by an umbilicus.

Apothecia scattered and immersed..... DERMATOCARPON (p. 242).

Apothecia clustered on a very short pedicel. GYROPHORA (p. 166).

Thallus not attached by an umbilicus.

Thallus small, closely adnate (scarcely plainly foliose).....Higher species of *LECANORA* (p. 171).

- Thallus usually larger, less closely attached.
- Spores commonly medium-sized and ellipsoid; thallus usually large and rather closely attached..... *PARMELIA* (p. 190).
- Spores commonly smaller, short or sub-spherical; thallus usually smaller and less closely attached..... *CETRARIA* (p. 199).
- Spores not simple.
- Spores 2-celled.
- Spores hyaline, the cells polar; thallus usually yellowish, varying toward gray..... *TELOSCHISTES* (p. 217).
- Spores brown, the cells not polar.
- Thalloid exciple usually of the color of the thallus, usually sea-green or brownish.. *PHYSCIA* (p. 224).
- Thalloid exciple blackening, thus becoming indistinct, except in sections; thallus sea-green..... *PYXINE* (p. 230).
- Spores muriform, brown or hyaline.
- Apothecia clustered on the large thallus..... *UMBILICARIA* (p. 168).
- Apothecia not clustered, immersed in the minute, not plainly foliose thallus..... *ENDOCARPON* (p. 244).
- Algal cells nearly always blue green (*Nostoc*, *Gloeocapsa*, *Polycoccus*, *Dactylococcus*, etc.).
- Algal symbiont *Nostoc*, showing the pseudocysts and heterocysts plainly; thallus becoming gelatinous when wet.
- Thallus having a cortex of a single layer of cells.. *LEPTOGIUM* (p. 139).
- Thallus without a cortex.
- Spores hyaline, several-celled, not muriform... *SYNECHOBLASTUS* (p. 133).
- Spores hyaline, more or less muriform at maturity..... *COLLEMA* (p. 136).
- Algal symbiont not *Nostoc*.
- Algal cells in groups (*Gloeocapsa*?) in the dark-colored thalli on rocks..... *OMPHALARIA* (p. 144).
- Algal cells in chains, the chains not easily discernible (*Polycoccus* or *Dactylococcus*, usually) in the commonly large thalli.
- Thallus cellular throughout, closely adnate... *HEPPIA* (p. 149).
- Thallus not cellular throughout.
- Thallus having cyphellæ or whitish spots on the lower side; spores 2 to 4-celled, hyaline or brown..... *STICTA* (p. 154).
- Thallus without cyphellæ or whitish spots below.
- Thallus with cellular cortex above and below.
- Spores simple, minute, numerous in each ascus; thallus small..... *ENDOCARPISCUM* (p. 148).
- Spores not minute, not numerous in each ascus.
- Spores simple, hyaline, ellipsoid; thallus small, of various colors.
- Some species of *PANNARIA* (p. 150).

- Spores brown or brownish, commonly 4-celled; thallus larger and usually brownish..... NEPHROMA (p. 164).
- Thallus without well-developed lower cortex.
- Thallus large, no lower cortex; spores long and slender, with 4 to 8 or more cells..... PELTIGERA (p. 159).
- Thallus sometimes showing a rudimentary lower cortex, smaller; spores commonly 2-celled..... SOLORINA (p. 158).
- Thallus wholly or partly fruticose or crustose.
- Thallus fruticose, or else 2-fold, in part fruticose and in part foliose or crustose.
- Thallus 2-fold, consisting of a fruticose portion and a foliose (squamulose) or a crustose portion.
- Thallus consisting of a fruticose portion (the podetium) and a foliose (squamulose) or rarely crustose portion, the latter frequently evanescent..... CLADONIA (p. 107).
- Thallus consisting of a fruticose portion (the stipe, strictly part of the fruit) and a crustose portion.
- Stipes well developed, very small and rarely branched.
- Spores spherical or subspherical.
- Spores colorless or only slightly colored..... CONIOCYBE (p. 45).
- Spores brown or brownish..... CHAENOTHECA (p. 48).
- Spores oblong or ellipsoid.
- Spores simple and hyaline..... BAEOMYCES (p. 105).
- Spores brown and usually 2-celled..... CALICIUM (p. 45).
- Stipes very short and seldom evident.
- Spores hyaline, 2 to 4-celled..... ICMADOPHILA (p. 106).
- Spores brown and 2-celled..... ACOLIUM (p. 51).
- Thallus consisting of a fruticose portion only, or (Pilocladium and Stereocaulon) also of an evanescent, horizontal portion rarely seen.
- Podetia present, clothed more or less with phyllocladia.
- Thallus small and rarely branched..... PILOPHORUS (p. 132).
- Thallus larger and much branched..... STEREOCAULON (p. 130).
- Podetia wanting.
- Algal symbiont, Sirospira, determining the form of the thallus and giving it a dark color EPHEBE (p. 146).
- Algal symbiont, Cystococcus, not determining the form or color.
- Branches cylindrical or compressed-cylindrical.
- Grayish to sea-green, or rarely reddish, rarely angular..... USNEA (p. 207).
- Commonly brownish to blackish, rarely sea-green..... ALECTORIA (p. 206).

Branches flattened.

Spores hyaline, simple.

Thallus sea-green, not conspicuously channelled..... EVERNIA (p. 202).

Thallus pale or darker brown, conspicuously channelled..... One species of CETRARIA (p. 199).

Spores 2-celled.

Spores brown; thallus usually sea-green.

One species of PHYSCIA (p. 224).

Spores hyaline.

Cells of spores proximate; thallus usually sea-green or grayish..... RAMALINA (p. 203).

Cells of spores polar; thallus more or less yellowish..... TELOSCHISTES (p. 217).

Thallus crustose.

Apothecia unknown; thallus rudimentary and sordidate..... AMPHILOMA (p. 247).

Apothecia well known and usually present.

Proper exciple produced into a perithecium; thal-
loid exciple absent or uncertain.

Apothecia immersed in the thallus and the peri-
thecium poorly developed or not discernible,
being usually replaced by an amphithecium.

Apothecia usually grouped in verrucæ; spores
very large..... PERTUSARIA (p. 187).

Apothecia occurring singly.

Spores simple, minute and many in each as-
cus, hyaline; thallus strictly crustose,
granular, greenish..... THELOCARPON (p. 241).

Spores muriform, hyaline or brown, large and
few in each ascus; thallus showing a cor-
tex in section..... ENDOCARPON (p. 244).

Apothecia partially or rarely entirely immersed
in the substratum or the thallus, but the peri-
thecium always well developed.

Spores hyaline, never muriform.

Spores simple; thallus well developed, ver-
rucose or areolate, the apothecia not
often completely immersed..... VERRUCARIA (p. 233).

Spores not simple.

Spores 2 to several-celled, ellipsoid to lin-
ear-oblong; thallus and apothecia
partly or mainly in the substratum... ARTHOPYRENIA (p. 236).

Spores 4 to several-celled, fusiform to acicu-
lar; thallus and apothecia as in Artho-
pyrenia..... SAGEDIA (p. 235).

Spores brown or muriform, or both.

Spores brown, 2 to several-celled; thallus and
apothecia partly or mainly in the sub-
stratum..... PYRENULA (p. 238).

Spores muriform, brown or rarely hyaline;
thallus conspicuous on the substratum
and the apothecia immersed more or less
in it..... STAUROTHELE (p. 246).

- Proper exciple absent or not produced into a perithecium; thalloid exciple frequently present.
 Apothecia surrounded by a thalloid exciple.
 Thalloid exciple well developed.
 Spores commonly simple. •
 Algal cells blue-green, in clusters (Gloeocapsa?); thallus inconspicuous, blackish, sometimes coralloid..... PYRENOPSIS (p. 143).
 Algal cells bright green (Cystococcus); thallus seldom blackish..... LECANORA (p. 171).
 Spores 2-celled.
 Spores hyaline, the cells usually polar; thallus commonly more or less yellowish..... PLACODIUM (p. 211).
 Spores brown, the cells not polar; thallus of various colors..... RINODINA (p. 220).
 Thalloid exciple doubtful or evanescent. •
 Spores simple. •
 Spores minute and numerous in each ascus; apothecia usually immersed and the thalloid exciple uncertain..... ACAROSPORA (p. 170).
 Spores very large, 1 to 8 in each ascus; apothecia embedded in verrucæ, and a thalloid exciple rarely discernible.... PERTUSARIA (p. 187).
 Spores not simple. •
 Spores hyaline.
 Spores 2-celled; the thalloid exciple evanescent or uncertain..... GYALECTA (p. 61).
 Spores more than 2-celled.
 Spores fusiform-acicular, 4 to 6-celled; the thalloid exciple inconspicuous or absent..... HAEMATOMMA (p. 185).
 and one species of SECOLIGA (p. 62).
 Spores cylindrical, elongated, many-celled; thalloid exciple usually evanescent..... CONOTREMA (p. 63).
 Spores not usually hyaline, muriform, many-celled; apothecia usually immersed..... URCEOLARIA (p. 231).
 and one species of SECOLIGA (p. 62).
 Apothecia without a thalloid exciple.
 Apothecia rounded.
 Spores hyaline.
 Spores simple.
 Spores either very large or very minute.
 Spores very large and one in each ascus; thallus roughened or verrucose..... MEGALOSPORA (p. 81).
 Spores very minute and many in each ascus; thallus commonly granular and inconspicuous..... BIATORELLA (p. 65).
 Spores medium-sized, 8 in each ascus; thallus granular, verrucose or areolate..... LECIDEA (p. 67).

spores escape thus before they have reached their full size and while yet colorless, and are doubtless nourished, in part at least, by the substance derived from the dissolved walls of the asci. The stipes are well developed except in the single genus *Acolium*, where they are very short.

The horizontal thallus is crustose and varies from rudimentary and inconspicuous to better developed and even areolate conditions, as in our common *Acolium tigillare*. The algal symbiont is *Cystococcus*, except in *Coniocybe*, where *Chroolepus* may occur instead. The fruticose stipe is strictly a part of the fruit.

The four genera of our flora placed in the family are certainly very closely related, forming a very distinct group of lichens. The plants are all minute and difficult to detect. They are certainly among the lowest lichens, and many of the species have been placed among other fungi by some authors.

The work on the genera *Calicium* and *Chaenotheca* in Minnesota has added conspicuously to known distribution.

CONIOCYBE Ach. Vet. Akad. Handl. 1816: 283. *pl. 8. f. 16.* 1816.

The horizontal thallus is crustose and may form a smooth film over the substratum or become more or less scurfy. In some of the species it is more or less evanescent, while in the more persistent and well developed forms it resembles the thalli of the *Chaenothecas* and is nearly as well developed. There is no cellular cortex, but the protective hyphal layer is well developed in some of the species. The algal symbiont Dr. Albert Schneider finds to be a form of *Chroolepus*, at least in certain plants examined. The thallus is more or less widely spread over the substratum as a continuous or more or less broken layer. The stipe is similar to that of *Calicium*.

The apothecia are similar in form to those of *Calicium*, but are usually ashy or yellowish, though brownish black apothecia exist in at least one species. The exciple, at least in our two American species, is light in color, and though it may inclose the apothecium in very young stages, tends to disappear, leaving the apothecium more or less biatoroid. The spores are simple, spherical, and hyaline or slightly colored.

Of the other members of the family, *Coniocybe* is plainly most closely related to *Chaenotheca*, both as to spore and thallus characters.

A single species occurs in the State.

Type species *Coniocybe brachypoda* Sch. op. cit. 287.

1. Coniocybe pallida (Pers.) Fr. Sched. Crit. Lich. Exsicc. Suec. 3. 1826.

Calicium pallidum Pers. Ann. Bot. Usteri 7: 20. 1794.

Thallus a thin, whitish crust, frequently spread over the substratum in irregular areas, but sometimes disappearing; stipes slender, about 1 to 2 mm. in length, whitish or yellowish, often brownish toward the top; apothecia minute or small, 0.15 to 0.3 mm. in diameter, the disk brownish and commonly convex, the exciple of the same color or lighter-pruinose, or in younger spheroidal apothecia both disk and exciple yellowish or whitish, or even white-pruinose; hypothecium pale or pale brownish; hymenium pale below but usually brownish above; paraphyses usually branched and neither enlarged nor colored toward the apex; asci cylindrical, soon dissolving; spores simple, spherical, hyaline, 3 to 7 μ in diameter.

Generally distributed over the State. In crevices on bark of old, rough-barked, deciduous trees.

Elsewhere in North America in New England, Illinois, and Iowa. Also in Europe.

CALICIUM Pers. Ann. Bot. Usteri 7: 20. 1794.

The horizontal thallus is crustose, but is rather inconspicuous, scarcely reaching anything more highly differentiated than a thin and minutely granulose condition, and is frequently very evanescent. It may be entirely wanting in parasitic species, and in these, as well as in some of the nonparasitic species, algal cells may be entirely

wanting, at least in the later stages of the life cycle. The forms that are devoid of the algal cells during more or less of the life period are frequently referred to other fungi, as are also forms of *Opegrapha* and certain parasitic species from other genera. The stipe is commonly well developed and is dark in color and quite slender. The algal symbiont is *Cystococcus*.

The apothecia are variously top-shaped, lentiform, or subspherical, and are borne at the top of the well-developed stipes. The exciple is dark in color and frequently, in the early development of the apothecium, almost incloses the then punctiform disk, when the apothecium forms essentially a perithecium. The disk is quite commonly more or less convex until after the spore masses are shed, when it usually becomes flat or even concave. The paraphyses are usually much branched and without apical color or thickening. Both simple and 2-celled spores occur in the genus, and even 4-celled and muriform spores are admitted by Tuckerman. In color the spores vary from a pale brown to a blackish brown.

The close relationship of *Calicium* to *Chaenotheca* and *Coniocybe* is apparent enough, and the present genus is also closely related to *Acolium*.

Seven species and subspecies occur in the State. On trees and old wood.

Type species *Calicium viride* Pers. loc. cit.

KEY TO THE SPECIES.

Parasitic on other lichens or on fungi; no thallus visible.

Stipes very short and stout; on *Pertusaria communis*..... 6. *C. turbinatum*.

Stipes longer and more slender than the last; on *Coriolus*

versicolor..... 7. *C. polyporaenum*.

Not parasitic on lichens or other fungi; thallus visible, whitish, often evanescent.

Stipes slender.

Apothecia top-shaped or lenticular..... 1. *C. parietinum*.

Apothecia usually subglobose..... 5. *C. pusillum*.

Stipes stouter.

Stipes very short..... 4. *C. curtum*.

Stipes not so short.

Disk often and the exciple usually white-pruinose. 3. *C. quercinum*.

Disk and exciple not pruinose..... 2. *C. trachelinum*.

1. *Calicium parietinum* Ach. Vet. Akad. Handl. 1816: 260. 1816.

Thallus very rudimentary, evanescent, when present indicated by whitish patches upon or in the substratum; stipes dark brown to black in color, 0.7 to 2 mm. in length; apothecia small or minute, 0.1 to 0.35 mm. across, top-shaped or lenticular, or in younger stages subspherical, the disk finally becoming convex, or flat with the dispersion of the spores, dark brown, the exciple dark brown and frequently ashy-pruinose below; hypothecium dark brown; hymenium pale below and brownish above; paraphyses frequently branched; asci cylindrical; spores simple, ellipsoid, pale blackish brown, 6 to 11 μ long and 3 to 6 μ wide.

Occurring throughout the State. On dead wood at some distance above the damp ground.

Distributed throughout North America. Known also in Europe.

2. *Calicium trachelinum* Ach. Lich. Univ. 237. 1810.

Calicium claviculare trachelinum Ach. Meth. Lich. 91. 1803.

Thallus ashy, thin, and granulose, commonly evanescent; stipes black or brownish black, rather longer and stouter than in the last; apothecia also rather larger than in the last, top-shaped or subglobose at maturity, the disk becoming brown and strongly convex before the spores are dispersed, the exciple dark in section and microscop-

ically reddish brown below; hypothecium dark brown; hymenium pale below and darker above; paraphyses distinct and commonly branched; asci cylindrical; spores brown or blackish brown, 2-celled, ellipsoid, commonly somewhat constricted at the septum, 7 to 12 μ long and 3 to 5 μ wide.

Throughout northwestern Minnesota. On dead cedar and tamarack wood in swamps.

Elsewhere in North America in New England, the Carolinas, Illinois, and Missouri. Known also in Europe and South America.

3. *Calicium quercinum* Pers. Tent. Disp. Fung. 59. 1797.

Thallus white or ashy, smooth, granulose or even scurfy, more or less evanescent; stipes black or brownish black, rather stout, and 0.6 to 1.8 mm. in length; apothecia small, 0.2 to 0.4 mm. in diameter, top-shaped or lentiform at maturity, the disk blackish brown or whitish-pruinose, nearly flat or quite convex, the exciple of the same color, but usually whitish-pruinose; hypothecium dark brown; hymenium pale below and brown above; paraphyses freely branching; asci irregularly clavate or cylindrical; spores brown or blackish brown, ellipsoid, 2-celled, 5 to 9 μ long and 3 to 5 μ wide, in some of ours referred here partly simple.

The plant referred here is common enough in northern Minnesota, and has been collected as far south as Granite Falls, but most of the material is doubtful and the thallus very scanty or entirely absent. Usually on dead wood. The subspecies *lentibulare* of the preliminary reports belongs partly above and in part with the next.

Elsewhere in North America in New England and Ohio. Found also in Europe.

4. *Calicium curtum* Borr. & Turn. Lich. Brit. 148. 1839.

Thallus a very thin granulose crust, ashy in color and becoming scarcely visible or entirely disappearing; stipes rather stout and in ours very short, scarcely exceeding 0.2 to 0.5 mm. in length, black; apothecia black throughout, like the last in form and size, but the black disk and exciple never pruinose in ours, the disk commonly flat; hypothecium dark brown; hymenium pale below and brown above; paraphyses commonly branched; asci cylindrical; spores blackish brown, 2-celled, ellipsoid, 7 to 12 μ long and 4 to 6 μ wide.

Nylander says that the margin of the exciple is white-pruinose. Ours in this respect is nearer the subspecies *lentibulare*, which is excluded from this volume (see under *C. quercinum*).

Collected at several places in northwestern Minnesota. On coniferous trees or the dead wood.

Elsewhere in North America in New England. Also found in Europe, South America, and New Zealand.

5. *Calicium pusillum* (Ach.) Floerke, Deutsch. Lich. 10: 6. 1821.

Calicium sphaerocephalum pusillum Ach. Meth. Lich. 92. 1803.

Thallus evanescent, but rarely to be made out as a whitish or ashy coloration upon the substratum; stipes slender and rather short, 0.3 to 0.6 mm. in length, black; apothecia minute, 0.1 to 0.2 mm. in diameter, subglobose or top-shaped lentiform, the disk brownish black and more or less convex, the exciple black or brownish black; hypothecium brown; hymenium pale below and brown above; paraphyses commonly branching freely; asci cylindrical; spores brown or blackish brown, ellipsoid, 2-celled, 6 to 10 μ long and 2 to 5 μ wide.

Collected in northern Minnesota at Henning, Rainy Lake City, and Tower. On dead cedars and tamaracks in swamps.

Elsewhere in North America in California, Quebec, Newfoundland, and Vancouver Island. Found also in Europe and Africa.

6. *Calicium turbinatum* Pers. Tent. Disp. Fung. 59. 1797.

Parasitic and no thallus distinguishable except that of the host; stipes very short, stout and black, the apothecia being often almost or perhaps rarely quite sessile upon the thallus of the host; apothecia small, 0.2 to 0.4 mm. in diameter, at maturity globose top-shaped, the disk in the mature and open apothecia flat and dull black, the exciple black, often with a lighter margin; hypothecium dark brown or brownish black; hymenium pale below and brown above; paraphyses simple or branched, commonly distinct; spores brown or blackish brown, simple, subglobose or rarely short-ellipsoid, 4 to 7 μ in diameter.

Throughout the cedar swamp areas of northern Minnesota. On *Pertusaria communis* on cedars in swamps.

Elsewhere in North America at New Bedford, Massachusetts, and in Canada, Alaska, and Newfoundland. Also in Europe and Africa.

7. *Calicium polyporaum* Nyl. Flora 58: 7. 1875.

PLATE 1, A.

Parasitic and no thallus distinguishable, at least in material examined; stipes and apothecia very similar to those of *Calicium parietinum*, but the present plant as a whole rather smaller, with the apothecia rather more narrowly top-shaped and the disk more commonly flat; hypothecium brown; hymenium pale below and brownish to dark brown above; paraphyses frequently branched; asci cylindrical; spores simple, brown, oblong-cylindrical, 9 to 18 μ long and 3 to 4.5 μ wide. Nylander says, "Sporae magis cylindraceo-oblongae quam in *C. parietino*, quo caractere constante *C. polyporaum* sit distinguendum."

Occurring throughout the northern one-third of the State. On *Coriulus versicolor* and closely related fungi.

A North American plant known elsewhere at New Bedford, Massachusetts, and in a few localities in Iowa.

EXPLANATION OF PLATE 1.—A, Plants of *Calicium polyporaum* on *Coriulus versicolor*. Apothecia on stipes. B, Plants of *Opegrapha varia* on white cedar, showing the apothecia and the whitish coloration due to the thallus. A enlarged 3 diameters; B, 1½ diameters.

CHAENOTHECA Th. Fr. Gen. Het. Eur. 102. 1861.

The thallus is as a whole much better developed than in *Calicium*, and is quite conspicuous and more like that of the species of *Acolium*, at least in most of our species. In one of ours in which the stipe is quite short the external resemblance between the two genera becomes quite marked. In the better developed species the thallus becomes a scattered or subcontinuous verrucose or even subareolate crust. In others it is granular or mealy. The algal symbiont is as usual in the family. The stipe is quite similar to that of the species of *Calicium*.

The apothecia are very similar to those of *Calicium*s, but the spores are uniformly simple and spherical or subspherical. They are brown or brownish.

The relationships have been sufficiently discussed above and in the descriptions of other genera of the family. The species were included with *Calicium* in the preliminary reports.

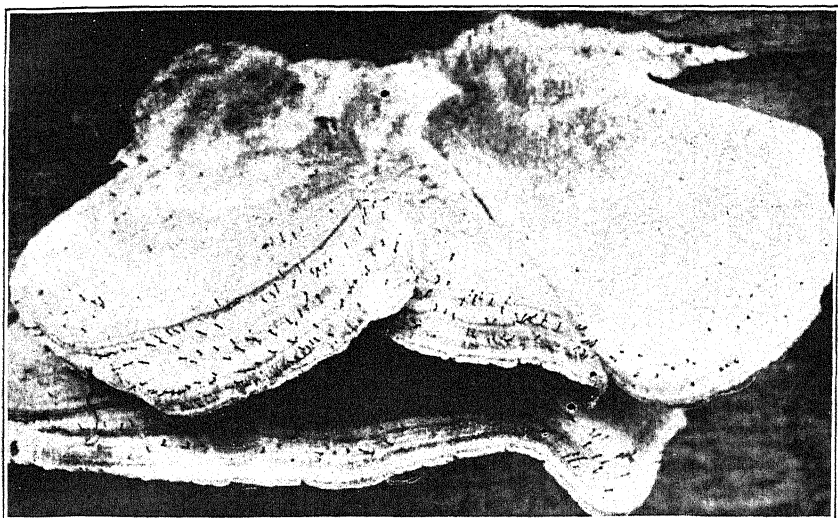
Eight species and subspecies are known in Minnesota, all occurring on living or dead coniferous wood in the northern portion of the State.

Type species *Chaenotheca chrysocephala* (Turn.) Th. Fr. loc. cit.

KEY TO THE SPECIES.

Thallus lemon-yellow to yellowish green.

- | | |
|----------------------------------|---------------------------------------|
| Stipes rather short | 1. <i>C. chrysocephala</i> . |
| Stipes longer and pruinose | 1a. <i>C. chrysocephala filaris</i> . |



A. *CALICIUM POLYPORAEUM* NYL.



B. *OPEGRAPHA VARIA* PERS.

Thallus ashy to ashy greenish or ashy yellow.

Thallus well developed, plainly granular.

Granules squamiform..... 2. *C. phaeocephala*.

Granules smaller, not so plainly squamiform..... 3. *C. trichialis*.

Thallus not well developed, rarely granular.

Thallus frequently disappearing.

Thallus evanescent and seldom seen..... 4. *C. brunneola*.

Thallus not so readily disappearing..... 2a. *C. phaeocephala trabinella*.

Thallus seldom or never disappearing.

Thallus thin and scurfy..... 3a. *C. trichialis stemonea*.

Thallus better developed and granulose..... 3b. *C. trichialis cinerea*.

1. *Chaenotheca chrysocephala* (Turn.) Th. Fr. Gen. Het. Eur. 102. 1861.

Lichen chrysocephalus Turn. Trans. Linn. Soc. Lond. 7: 88. pl. 8. f. 1. 1804.

Thallus lemon-yellow or yellowish green, granulose or verrucose, the granules or verrucæ varying from conglomerate to scattered; stipes rather short, 0.35 to 1.2 mm. in length, black or dark brown, sometimes slightly greenish-pruinose, longer in some other North American material; apothecia minute, 0.1 to 0.25 mm. across, top-shaped or younger conditions spheroidal, at maturity the disk dark brown and flat or slightly convex, the exciple blackish brown, and yellowish or greenish-pruinose below as is often the top of young and spheroidal apothecia; hypothecium dark brown; hymenium pale to pale brownish; paraphyses often more or less coherent, simple and neither thickened nor colored toward the apex; asci cylindrical; spores more or less brown, 3 to 6 μ in diameter.

Distributed throughout the pineries of northern Minnesota. On living and dead coniferous wood, especially pine wood and bark.

Elsewhere in North America at New Bedford, Massachusetts. Known also in Europe.

Calicium chrysocephalum of the preliminary reports.

1a. *Chaenotheca chrysocephala filaris* (Ach.) Fink.

Calicium chrysocephalum filare Ach. Lich. Univ. 239. 1810.

Thallus scattered and granular, yellowish; both stipe and apothecium rather elongated and slightly pruinose.

Collected at Tofte. On dead wood.

Not known elsewhere in North America. Found also in Europe.

Calicium chrysocephalum filare of the preliminary reports.

2. *Chaenotheca phaeocephala* (Turn.) Th. Fr. Nov. Act. Soc. Sci. Ups. III. 3: 351. 1861.

Lichen phaeocephalus Turn. Trans. Linn. Soc. Lond. 8: 260. pl. 6. f. 1. 1807.

Thallus ashy or dirty-yellow, frequently quite thick, composed of small scattered or clustered squamiform granules, which may even show more or less crenate margins; stipes longer than in the last, 0.4 to 2.5 mm. in length, black or brownish black, rarely paler or quite pale toward the base, sometimes thinly and yellowish green pruinose, especially toward the top; apothecia somewhat larger than in the last, reaching 0.3 mm. in diameter, the form of young and mature ones also as in the last, the disk at maturity convex and dark brown, the exciple dark brown and yellowish green-pruinose or becoming naked with age; hypothecium dark brown; hymenium pale below and brownish above; paraphyses simple or branched, without apical color or thickening; asci cylindrical; spores brown or brownish, spherical or spheroidal, 3 to 5 μ in diameter or one dimension reaching 6 μ .

Collected along the northern boundary at Beaudette and Emo. On cedars in swamps.

Elsewhere in North America in British America and New England. Also in Europe.

Calicium phaeocephalum of the preliminary reports.

2a. *Chaenotheca phaeocephala trabinella* (Ach.) Fink.

Calicium xylonellum trabinellum Ach. Meth. Lich. 93. 1803.

Thallus of smaller and scattered granules and often disappearing; stipes commonly longer.

With the last and perhaps more common.

Not known elsewhere in North America. Found also in Europe.

Calicium phaeocephalum trabinellum of the preliminary reports; *Calicium trabinellum* of the reports is likewise the same.

3. *Chaenotheca trichialis* (Ach.) Th. Fr. Nov. Act. Soc. Sci. Ups. III. 3:351. 1861.

Calicium trichiale Ach. Lich. Univ. 243. 1810.

Thallus from ashy varying toward yellowish green or sea-green, squamulose-granular as in the last, but the granules smaller and usually more scattered; stipes black or blackish brown, 0.3 to 2 mm. in length; apothecia at maturity with a very convex disk, giving the whole structure a globose-lenticular form, of about the same size as in the last, both the disk and the exciple dark brown, or the exciple ashy-pruinose below; hypothecium dark brown; hymenium pale below and brownish above; paraphyses coherent and indistinct in the material examined; asci cylindrical; spores spherical, brown or brownish, 2.5 to 5 μ in diameter.

Collected in northeastern Minnesota at Rose Lake, Snowbank Lake, and at Beaver Bay. On coniferous wood.

Elsewhere in North America at New Bedford, Massachusetts, and in Quebec and Ontario. Known also in Europe.

Calicium trichiale of the preliminary reports.

3a. *Chaenotheca trichialis stemonea* (Ach.) Fink.

Calicium trichiale stemoneum Ach. Lich. Univ. 243. 1810.

Thallus thin and scurfy, yellowish or yellowish green, otherwise as above.

Once collected, at Ely. On pines.

Not known elsewhere in North America. Found also in Europe.

Calicium trichiale stemoneum of the preliminary reports.

3b. *Chaenotheca trichialis cinerea* (Pers.) Fink.

Calicium cinereum Pers. Icon. Descr. Fung. 58. 1800.

Thallus granulose; stipes commonly brown and apothecia of the same color or ashy-pruinose below, as the stipes may also be; spores perhaps larger.

The most common form of the species, no doubt occurring throughout the coniferous woods in northern Minnesota. On living and dead coniferous wood.

Not known elsewhere in North America. Found also in Europe.

Calicium trichiale cinereum of the preliminary reports.

4. *Chaenotheca brunneola* (Ach.) Müll. Arg. Mém. Soc. Phys. Hist. Nat. Genève, 16²:360. 1862.

Calicium brunneolum Ach. Vet. Akad. Handl. 1816:279. 1816.

Thallus very thin, ashy or greenish, of minute granules, evanescent and seldom seen; stipes very slender and often much elongated, becoming 5 mm. in length, black; apothecia as those of the last species above as to form, color, and rarely as to pruinose condition; hypothecium brownish black; hymenium pale below and brownish above; paraphyses distinct and frequently branched in the material examined; asci cylindrical; spores spherical or spheroidal, 2.5 to 4 μ in diameter, the longer dimension

reaching 5μ . Considered by Nylander to be a subspecies of the last, and certainly very near.

Collected in northeastern Minnesota at Two Harbors, Ely and about Snowbank Lake. On decorticated coniferous wood.

New Bedford, Massachusetts, is the only other North American locality. Known also in Europe.

Calicium brunneolum of the preliminary reports.

ACOLIUM S. F. Gray, Nat. Arr. Brit. Pl. 1: 482. 1821.

The thallus is crustose and verrucose, or more commonly more or less distinctly areolate, with the areoles usually forming a continuous crust. There is no cellular cortex and no algal nor medullary layers, yet the thallus is rather thick and much better developed than in either *Calicium* or *Coniocybe*, and more like that of *Chaenotheca*. The thallus seldom or never becomes inconspicuous or disappears, except in a few parasitic species, from which it seems to be entirely absent. The algal symbiont is the form of *Cystococcus* usually found in members of the present family.

The apothecia are borne upon a very short stipe, and both stipe and apothecium are frequently embedded in the thallus, so that there seems to be simply the immersed apothecia, the peculiar structure in such instances only appearing in vertical sections through stipe and apothecium. In all of the species is found the dark proper exciple, and in those having the stipe and apothecium immersed in the thallus it is usual to think of the surrounding thallus layer as a thalloid exciple. The disk is more or less concave, even reaching cup-shaped conditions. Both simple and 2-celled spores are found in plants commonly admitted to the genus, and not infrequently the whole range of forms from the simple spore to the muriform condition is included in the one genus. This mass of forms is in need of careful revision, but our flora presents no difficulty in this regard, as we have but two species, these with the usual 2-celled brown spores. The asci dissolve while the spores are quite immature.

The close relationship of the present genus to *Chaenotheca*, *Calicium*, and *Coniocybe* is apparent enough in species of *Acolium*, having the short stipe exposed above the thallus, and is just as apparent in such species as ours when studied in section.

Two species are found in Minnesota. On old pine boards, posts, and trees.

Type species *Acolium tigillare* (Ach.) S. F. Gray, loc. cit.

KEY TO THE SPECIES.

- Stipes very short and apothecia immersed..... 1. *A. tigillare*.
Stipes longer and apothecia sessile or slightly elevated..... 2. *A. lucidum*.

1. *Acolium tigillare* (Ach.) S. F. Gray, Nat. Arr. Brit. Pl. 1: 482. 1821.

Lichen tigillaris Ach. Lich. Suec. 67. 1798.

Thallus yellowish green or lemon-yellow, crustose, and usually quite prominent, chinky and soon becoming areolate, or rarely granular, commonly widely spread over the substratum as a continuous or more or less broken layer; apothecia small, 0.3 to 0.6 mm. in diameter, on very short stipes, both apothecia and stipes being immersed in the thallus in areolate thalli, one or more apothecia in each areole, or rarely more or less superficial, the disk dull black and flat or somewhat concave, the proper exciple black; hypothecium dark brown; hymenium pale or slightly colored; paraphyses rather short and slender and commonly simple, with scarcely enlarged or colored apex; asci long, cylindrical, soon dissolving; spores blackish brown, 2-celled, constricted at the septum, 12 to 20μ long and 7 to 10μ wide.

Widely distributed in the State, and to be looked for wherever boards or posts of pine fences have stood long enough for the plant to become established.

Throughout the eastern portion of North America from the Gulf of Mexico to the Arctic Ocean. Known also in Europe.

2. *Acolium lucidum* (Th. Fr.) Fink.

Trachylia lucida Th. Fr. Öfv. Vet. Akad. Förh. 12: 18. 1855.

Thallus crustose, verrucose, scarcely reaching an areolate condition, the verrucae usually more or less scattered upon the substratum, but sometimes forming a continuous crust over small areas of the substratum, lemon-yellow or yellowish green; apothecia of about the same size as those of the last, but on somewhat longer stipes, so that the apothecium appears to be sessile upon the thallus or rarely elevated sufficiently so that the stipe may be seen without sectioning, the disk flat and at first bluish green pruinose, the exciple black and prominent; hypothecium dark brown; hymenium pale and frequently brownish above; paraphyses coherent and indistinct in ours examined; asci cylindrical or irregularly cylindrico-clavate; spores brown, 2-celled, ellipsoid, 6 to 9 μ long and 3 to 4 μ wide.

In northern Minnesota. On pines and other conifers and on dead wood.

Not known elsewhere in North America. Also in Europe.

Calicium lucidum of the preliminary reports.

Family GRAPHIDACEAE.

The characters by which the Graphidaceae may most readily be distinguished are those of the apothecia. These organs are commonly elongated or irregular and often branched. Yet a few somewhat rounded apothecia are occasionally seen in some of the species. These remind one of those of *Melaspilea*, but in ours at least the spore characters will always serve to distinguish very easily. Likewise, the clustered apothecia of *Gyrophora* remind one externally of those of some members of the present family, but sections of the apothecia of the *Gyrophoras* reveal a higher type of structure, and the differences in thalli in the Graphidaceae and the *Gyrophoraceae* are easily observable.

The thallus is crustose and usually hypophloeodal in our species, though some species not found in our flora occur on rocks. The structure of the thallus is quite rudimentary, as there is seldom any sign of differentiation. The algal symbiont is *Chroolepus*. The thallus characters are substantially the same as in the *Pyrenulaceae*, but in that family we have the spheroidal apothecia provided with a well-developed perithecium, by which difference the two families are to be distinguished. The spore characters are sufficiently explained in the outline of the families.

It is not at all probable that the genera of the family all had a common origin, and yet both the apothecial and the thallus characters would seem to indicate a close relationship.

The family is mainly southern in distribution, and the number of genera and species found in Minnesota is not large. The plants usually occur on smooth bark. *Graphis scripta* is by far the most common member of the family in Minnesota.

OPEGRAPHIA Humb. Fl. Friberg. 57. 1793.

The thallus is crustose and mainly hypophloeodal, forming a smooth crust upon the substratum when the epiphloeodal portion of the thallus is not entirely wanting, devoid of differentiation into layers, and, as usual in such low lichens, the hyphal rhizoids extending some distance into the substratum. The algal symbiont is a form of *Chroolepus*.

The apothecia are linear, oblong, or more or less rounded or irregular, rarely branched, with a usually narrowly furrowed or concave disk, superficial or more or less immersed in the substratum. The proper exciple is black, heavy, and prominent. The spores are 4 or more celled, and fusiform, ellipsoid, or finger-shaped, though some lichenists include in the genus similar lichens having persistently 2-celled spores.

The genus is plainly most closely related to *Graphis*, though its relation to *Arthonia*, *Melaspilea*, and *Lecanactis* is not remote.

Four species and subspecies have been found in Minnesota.

Type species *Opegrapha vulgaris* Humb. loc. cit. This is a synonym for *Graphis scripta*, and the name *Opegrapha* becomes invalid and will need to be changed when all lichen genera have been typified.

KEY TO THE SPECIES.

- Parasitic on other lichens..... 2. *O. quaternella*.
 Not parasitic on other lichens.
 Apothecia lanceolate..... 1. *O. varia*.
 Apothecia not lanceolate.
 Apothecia oblong-ellipsoid..... 1b. *O. varia pulicaris*.
 Apothecia oblong or suborbicular..... 1a. *O. varia notha*.

1. *Opegrapha varia* Pers. Ann. Bot. Usteri 7:30. 1794. • PLATE 1, B.

Epiphyllœodal portion of the thallus a thin whitish film forming a continuous or more or less scattered layer upon the substratum, or disappearing; apothecia lanceolate, small, 0.2 to 0.4 mm. wide and 0.4 to 1.5 mm. long, adnate or more or less immersed in the substratum, the disk black and usually more or less furrowed, the exciple black and prominent, persistent and heavy; hypothecium blackish brown; hymenium pale below and darker above; paraphyses rarely branched, sometimes more or less coherent, commonly enlarged and darkened toward the apex; asci clavate or cylindrico-clavate; spores hyaline or brownish, 4 to 6-celled, fusiform, 15 to 24 μ long and 5 to 8 μ wide.

Generally distributed in the State. On trees.

Also distributed throughout North America. Known also in Europe and Africa.

EXPLANATION OF PLATE 1. See page 48.

1a. *Opegrapha varia notha* (Ach.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 253. 1861.

Lichen nothus Ach. Lich. Suec. 19. 1798.

This form is distinguished by the oblong or suborbicular apothecia.

Collected at Rose Lake in the northeastern portion of the State. On cedars.

Does not appear in any American lichen lists known to me, though it is credited to our continent by Europeans. Occurs in Europe and Africa.

1b. *Opegrapha varia pulicaris* (Ach.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 253. 1861.

Opegrapha vulvella pulicaris Ach. Lich. Univ. 251. 1810.

Distinguished by the oblong-ellipsoid apothecia with commonly connivent exciple. The apothecia are smaller in ours. Determined by A. Zahlbruckner.

Collected at Granite Falls. On trees. There may well be some doubt as to the worth of these subspecies, but such as they are, they doubtless are to be looked for elsewhere in Minnesota.

Elsewhere in North America in New England, Ohio, Iowa, and Nebraska. In all the grand divisions except South America.

2. *Opegrapha quaternella* Nyl. Flora 68: 449. 1885.

Parasitic and no thallus discernible except that of the host; apothecia irregular in form and usually densely clustered, minute, 0.2 to 0.3 mm. in diameter, irregularly oblong where sufficiently distinct to show form, the exciple black and irregular; hypothecium dark brown; hymenium more or less brown or brownish; paraphyses distinct and rarely branched, commonly enlarged and darker toward the apex; asci clavate; spores 4 in each ascus, hyaline, oblong or oblong-ellipsoid, 16 to 22 μ long and 5 to 7 μ wide.

Collected once at Emo along the northern boundary. On *Peltigera aphthosa*.

A North American lichen known elsewhere at New Bedford, Massachusetts, and at Fayette, Iowa.

GRAPHIS Adans. Fam. Pl. 2: 11. 1763.

The thallus is similar to that of *Opegrapha*, being hypophloeodal in part and devoid of differentiation into layers. A thin epiphloeodal portion usually spreads over the substratum as a film. The algal symbiont is, as usual in the family, similar to that of *Opegrapha*.

The apothecia are linear, usually curved, and not infrequently more or less branched, shorter and even suborbicular forms occurring rather rarely. They may be immersed in the substratum completely or only slightly. The proper exciple is dark and perhaps most commonly black, at least above, and is usually crowned by a portion of the epiphloeodal thallus film, which may be regarded as a thalloid exciple. The disk is closed or narrowly linear and commonly black. The spores are usually composed of 6 or more cells, though 4-celled forms occur, and even muriform-spored lichens are included in the genus by lichenists. In form the spores are commonly oblong-ellipsoid, and the exosporium is often wavy, giving the spore a sort of caterpillar-like form. Both hyaline and more or less brownish spores occur within the genus.

The similarity between *Graphis* and *Opegrapha* is apparent enough, and the present genus seems also to show a somewhat close relationship with such genera as *Conotrema* and *Megalospora*, where we find similar spores and more or less evanescent thalloid exciples surrounding the proper exciples.

Mr. W. W. Calkins has recognized four species within the State, but two of these are plainly the common *Graphis scripta*, and a third perhaps another form of the same species. Ours all occur on trees.

Type species *Lichen scriptus* L. (*Graphis scripta* (L.) Ach.)

Based on *Lichenoides* Dill. Musc. pl. 18. f. 1, 2. 1741, figure 1, being identified in L. Sp. Pl. 1140. 1753.

KEY TO THE SPECIES.

- Epiphloeodal portion of the thallus rather thick; not widely spread..... 1b. *G. scripta serpentina*.
 Epiphloeodal portion of the thallus thin, usually widely spread.
 Apothecia radiately branched or radiately arranged... 2. *G. dendritica*.
 Apothecia not radiately branched nor radiately arranged.
 Apothecia variously curved, sometimes branched. 1. *G. scripta*.
 Apothecia straight and parallel..... 1a. *G. scripta recta*.

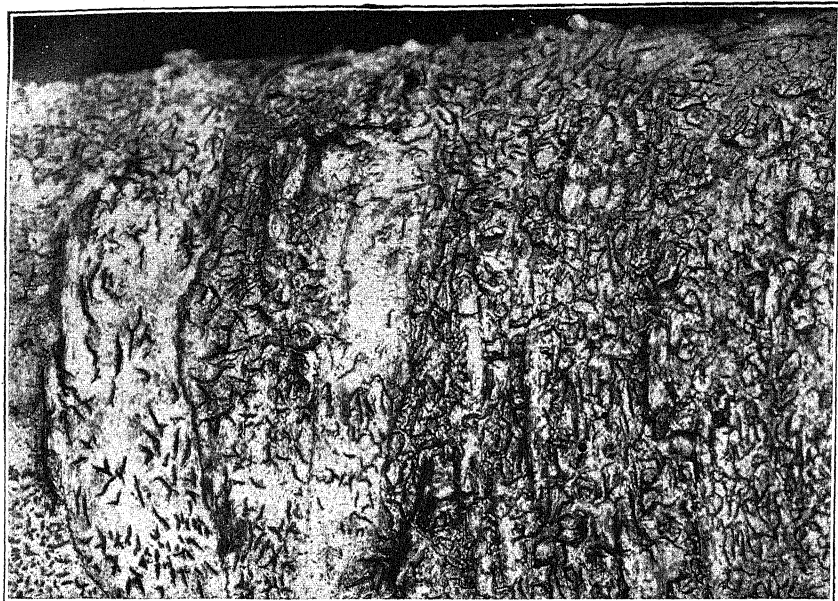
1. *Graphis scripta* (L.) Ach. Lich. Univ. 265. 1810.

PLATE 2, A.

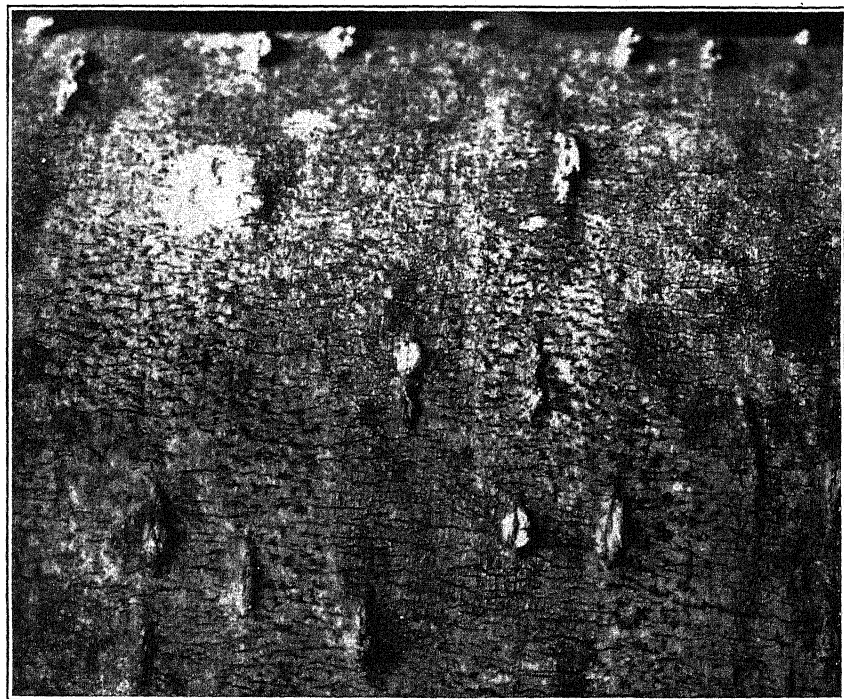
Lichen scriptus L. Sp. Pl. 1140. 1753.

Thallus commonly showing plainly as a smooth, thin, whitish, ashy, or more rarely somewhat olivaceous crust, this either limited or widely spread over the substratum; apothecia usually much elongated, variously curved, sometimes branched, about 0.2 mm. in width and often 3 mm. or more in length, more or less superficial, the disk linear and appearing as a closed and often pruinose furrow, the proper exciple commonly veiled by the thin thalloid one; hypothecium dark brown; hymenium pale or pale brownish; paraphyses simple or rarely branched, frequently enlarged and darkened toward the apex; asci clavate or cylindrico-clavate; spores hyaline, oblong to linear with rounded ends, the exosporium wavy, usually 7 to 10-celled, 20 to 40 μ long and 7 to 9.5 μ wide.

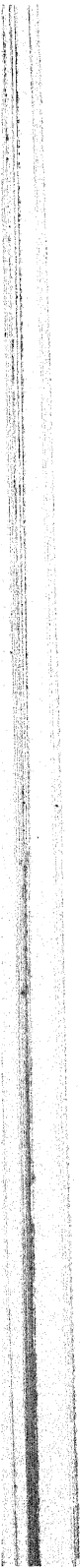
Generally distributed over the State. On trees.



A. *GRAPHIS SCRIPTA* (L.) ACH.



B. *ARTHONIA RADIATA* (PERS.) ACH.



Also generally distributed throughout North America, and cosmopolitan in its foreign distribution.

EXPLANATION OF PLATE 2.—A, Plant of *Graphis scripta* on balsam fir, showing the elongated and variously curved apothecia and the whitish coloration due to the thallus. B, Plants of *Arthonia radiata* on balsam fir, showing the irregular apothecia and the whitish coloration due to the thallus. A enlarged $1\frac{1}{2}$ diameters; B enlarged $1\frac{1}{2}$ diameters.

1a. *Graphis scripta recta* Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 252. 1861.

Apothecia straight and parallel or nearly so, in ours longer and often reaching 5 to 10 mm. in length; in ours also the epiphloeodal portion of the thallus, including the thalloid exciple, wanting, so that there appears to be no thallus.

It seems probable that this form might better have retained the status of a species.

Throughout the northern portion of the State. On birches.

Distributed throughout the northern part of the United States and British America. Known also in Europe and Asia.

1b. *Graphis scripta serpentina* (Ach.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 252. 1861.

Lichen serpentinus Ach. Lich. Suec. 26. 1798.

The epiphloeodal portion of the thallus unusually well developed, whitish and immersing the apothecia, and usually occurring in rather small areas upon the substratum.

Generally distributed over the State. On trees.

It is not possible to state the North American distribution of this subspecies, as it has been generally misunderstood. Our subspecies *limitata* of the preliminary reports undoubtedly belongs here, as the limiting dark line is almost uniformly wanting. Doubtless also the large number of specimens from British America called subspecies *limitata* are the present subspecies.

Known in all the grand divisions except Africa.

2. *Graphis dendritica* Ach. Lich. Univ. 271. pl. 3. f. 16. 1810.

Opegrapha dendritica Ach. Meth. Lich. 31. pl. 1. f. 10. 1803.

Thallus largely hypophloeodal, and the epiphloeodal film much as in the last species; apothecia more commonly immersed in the substratum and copiously radiate-branched, or in the less developed forms clustered, the cluster forming the radiate arrangement, and the individual apothecium less branched, the disk and proper exciple much as in the last species, but the thalloid veil rather less frequently present; internal characters also as in the last, but the spores shorter, containing fewer cells, and becoming colored and even dark-colored with age (4 to 8-celled, and 20 to $36\ \mu$ long and 5 to $8\ \mu$ wide).

Some of the material referred to *Graphis scripta limitata* in the preliminary reports may belong here, but a plant from Spicer County determined by Mr. W. W. Calkins appears much nearer this species externally. The spores of the latter, however, occasionally reach 10-celled conditions and they show only an occasional trace of color. On the other hand, a plant collected at Beaudette and less well marked externally shows the shorter, fewer-celled spores. Similar specimens have been collected in Illinois, Iowa, and Nebraska, but none of these northern plants are so well marked as those from the South, and it may well be doubted whether the species really occurs in any of these States.

Widely distributed in the Southern States and occurring all along our Atlantic coast. Also in Europe, Asia, and South America.

ARTHONIA Ach. Neu. Journ. Bot. Schrad. 1³: 3. pl. 4. 1806.

The thallus is rudimentary in structure and never shows any indication of cortical tissues. It is hypophloeodal in its early development and remains at least partly so in a large number of species. Under the best conditions it may become crustose and

in a few species it is sometimes areolate. The algal symbionts may be either *Cystococcus* or *Chroolepus*, and the relation between the fungal and the algal symbionts is unusually close, the algal cells or clusters being commonly entirely surrounded by fungal hyphæ or by haustoria. The thallus may be entirely dead and unnoticeable or quite prominent even in mature states. •

The apothecia are sessile or more or less sunken in the substratum, or may even be covered by a thin layer of the substratum or the thallus. They are usually minute or small and most frequently irregular in form, though they may present a rounded condition and become quite biatoroid in external appearance. Stellate and linear forms are quite common. They are black or brownish black in ours, though other colors are frequent in other species. The hypothecium is usually brown, but may be darker or quite pale. The hymenium is pale, varying to brown. The paraphyses are usually branched and frequently scarcely differ from the fungal hyphæ in general appearance. The asci are commonly of the peculiar pyriform or subpyriform shape. The spores have 2, 4, or rarely more numerous cells, and are of the peculiar oblong-ovoid form frequently called slipper-shaped or soleæform. They are hyaline, pale, or rarely brown or brownish.

The genus is closely related to *Arthothelium*, as appears in the structure of the apothecia and the nature of the thallus. Perhaps it would be more consistent to separate the 2-celled species under the genus *Coniangium* Fr.^a *Arthonia* properly stands next to *Arthothelium*, but is scarcely higher than *Opegrapha* and *Graphis*.

The genus is southern in range, and only 6 or 7 forms have been found in Minnesota.

The plants are found on trees, usually species with smooth bark.

Type species *Arthonia versicolor* Ach. loc. cit. The plant is uncertain, but the plate shows a plant externally like *Arthonia radiata* (Pers.) Th. Fr.

KEY TO THE SPECIES.

- Thallus epiphloeodal..... 4. *A. lecideella*.
- Thallus mainly or wholly hypophloeodal.
 - Spores 2-celled.
 - Apothecia rounded..... 1. *A. patellulata*.
 - Apothecia varying from rounded to some other form.
 - Apothecia rounded to round-oblong..... 2. *A. convexella*.
 - Apothecia rounded to difform..... 3. *A. dispersa*.
 - Spores 4-celled (rarely more).
 - Apothecia tending toward rounded forms..... 6a. *A. radiata swartziana*.
 - Apothecia not rounded.
 - Apothecia oblong, difform, or sublinear..... 5. *A. punctiformis*.
 - Apothecia difform, stellate, or ramose..... 6. *A. radiata*.

1. *Arthonia patellulata* Nyl. Nya Bot. Notis. 1853: 95. 1853.

Thallus occurring in patches from 6 to 40 mm. across, white or varying toward sea-green or olivaceous, mostly hypophloeodal or quite conspicuous and thick above the substratum, sometimes dying away, the thicker conditions usually more or less roughened; apothecia black, rounded, adnate or immersed, plane, minute or small, 0.3 to 0.6 mm. in diameter; hypothecium brownish to brownish black; hymenium pale or more commonly brownish; paraphyses somewhat gelatinized, but more or less branched and scarcely differing from the fungal hyphæ; asci broadly clavate to subpyriform; spores 2-celled, soleæform, 10 to 14 μ long and 3 to 5 μ wide.

The forms with thick dark thalli may belong to *Arthonia ruderalis* Nyl. ^b

^aFries, Syst. Orb. Veg. 27. 1825.

^bMem. Soc. Sci. Nat. Cherb. 4: 100. 1856.

Collected in several widely separate portions of the State and no doubt generally distributed. The plant resembles certain *Lecideas* externally and is easily overlooked. On trees, especially on poplars.

The species is reported from widely separate portions of North America, but neither from the extreme north or south. Also known in Europe.

2. *Arthonia convexella* Nyl. Act. Soc. Linn. Bord. 2: 415. 1856.

Thallus white, ashy, or greenish, partly epiphloeodal but thin and smooth and frequently dying away, the patches in material examined scarcely exceeding 20 or 30 mm. across; apothecia black, rounded or rounded-oblong, convex and rugulose, minute, 0.2 to 0.4 mm. in diameter; hypothecium heavy and blackish brown; hymenium brown or reddish brown; paraphyses usually branched and resembling the hyphæ, the apex brownish; asci broadly clavate or subpyriform; spores 2-celled, hyaline to brown, soleæform, 11 to 14 μ long and 4 to 6 μ wide.

Differs from ours of the last in the brown spores and the smaller, more convex apothecia.

Once collected in the State at Beaudette, along the international boundary, on balsam.

The only other station for the plant found reported is in France.

3. *Arthonia dispersa* (Lam. & DC.) Duf. Journ. Phys. Chem. Nat. Hist. 87: 203. 1818.

Opegrapha dispersa Lam. & DC. Fl. Fr. ed. 3. 2: 308. 1805.

Thallus white or whitish, mainly hypophloeodal, thin, smooth, occurring in patches from 6 to 70 mm. in longest dimension, or these running together and covering larger areas; apothecia punctiform, rounded, oblong, difform, or even branched, commonly more or less immersed in the thallus or the substratum, minute, the dimensions 0.1 to 0.4 mm.; hypothecium thin, pale or pale brownish; hymenium pale or very pale brownish; paraphyses not distinctly seen, probably merely a mass of more or less gelatinized hyphæ; asci pyriform; spores 2-celled, soleæform, 11 to 16 μ long and 4 to 5 μ wide.

The most common and most widely distributed of the genus in Minnesota. On trees, especially common on *Acer spicatum* in the northern portion of the State.

Apparently generally distributed throughout the United States, and extending at least as far north as Newfoundland. Known also in Europe.

4. *Arthonia lecideella* Nyl. Mém. Soc. Sci. Nat. Cherb. 5: Suppl. 337. 1857.

Thallus greenish to sea-green or lighter, rather thick, continuous or rarely subareolate, uneven and epiphloeodal, occurring in irregular patches 5 to 25 mm. in the longest diameter and sometimes running together and covering larger areas of the substratum; apothecia dark brown or black or frequently grayish-pruinose, quite numerous, plane or convex, rounded, small, 0.2 to 0.4 mm. in diameter, immersed or adnate; hypothecium brown or dark brown; hymenium light brown or at least brownish; paraphyses short-jointed and freely branched, the apices of the branches sometimes enlarged and darker; asci clavate to subpyriform; spores soleæform, 4-celled, 16 to 23 μ long and 5 to 6.5 μ wide.

Generally distributed over the State. On trees and old wood.

A strictly North American lichen, common in the Mississippi Valley, ranging eastward to the Atlantic and northward into British America.

5. *Arthonia punctiformis* Ach. Lich. Univ. 141. 1810.

Thallus mainly hypophloeodal and finally dying away, when present giving a whitish cast to the substratum, occurring in irregular patches frequently reaching 75 mm. or more in the longest dimension; apothecia oblong, sublinear or more commonly difform or even rounded, black, plane or slightly convex, adnate or immersed, minute, 0.1 to

0.2 mm. in diameter or in the short dimension of the elongated forms; hypothecium pale or pale brownish; hymenium pale; paraphyses scarcely differing from the hyphæ of the thallus; asci pyriform or subpyriform; spores 4-celled (or rarely 5 or 6-celled), soleæform, 15 to 22 μ long, 4.5 to 7 μ wide.

Generally distributed over the State. On trees and confined to smooth bark. A number of subspecies have been recognized based on the number of cells in the spores and the form of the apothecia.

Distributed throughout North America, except possibly the extreme north. Also well known in Europe and Asia.

6. *Arthonia radiata* (Pers.) Ach. Lich. Univ. 144. 1810.

PLATE 2, B.

Opegrapha radiata Pers. Ann. Bot. Usteri 7: 29. 1794.

Thallus sea-green varying toward whitish or brownish, partly or wholly hypophloeodal and rarely entirely dying away, occurring in more or less irregular patches, reaching 5 to 30 mm. in diameter and rarely bordered wholly or in part by a dark line, the thalli frequently running together and covering much larger areas of the substratum; apothecia stellate, difform, or ramose, adnate or more commonly immersed, rarely erumpent, black, plane or slightly convex, rather large for the genus, 0.4 to 1.5 mm. in the longest dimension; hypothecium pale brown; hymenium pale or brownish; paraphyses simple or branched, with enlarged brownish apex; asci broadly clavate or subpyriform; spores 4-celled, soleæform, 12 to 20 μ long and 4 to 6 μ wide.

Generally distributed over the State. On trees, confined to smooth bark and usually to rather young trees.

The plant is widely distributed in North America and is general in its foreign distribution also. Several subspecies are recognized, few of which seem to have any value.

EXPLANATION OF PLATE 2.—See page 55.

6a. *Arthonia radiata swartziana* (Ach.) Willey, Syn. Arth. 44. 1890.

Arthonia swartziana Ach. Neu. Journ. Bot. Schrad. 1³: 13. pl. 4. f. 1. 1806.

Apothecia larger and more commonly rounded; spores also rather larger.

What seems to be this subspecies was collected in the northern portion of the State at Rainy Lake City and at Tower. Habitat same as that of the species.

Widely distributed in the United States and British America. Also known in Europe and Africa.

ARTHOTHELIUM Mass. Ric. Lich. 54. f. 101. 1852.

Like *Arthonia*, the genus has a rudimentary thallus without cortical tissues. But the thallus is on the whole better developed than in the foregoing genus, commonly becomes largely or wholly epiphloeodal, and rarely, if ever, entirely disappears. It is frequently quite thick and uneven and rarely even areolate. The algal symbiont is *Chroolepus*, at least so far as has been ascertained.

The apothecia are adnate, or more or less sunken in the thallus or substratum. They are usually small and rounded or irregular in outline. The color is black or rarely brownish black. The hypothecium is usually brown, though it may vary to dark brown or pale. The hymenium is pale to brown. The paraphyses are usually much branched, but are quite commonly simple in some species. The asci are usually of the peculiar pyriform or subpyriform shape. The spores are many-celled and muriform, large in size, and still quite constantly 8 in each ascus, and they may be hyaline, pale, or brown in color.

The genus is closely related to *Arthonia* as to structure of thallus and yet more as regards the apothecia. Though the spores are usually quite different and apparently

nearer Dermatocarpon and related genera, there are submuriform conditions which seem to bridge over the gap between Arthothelium and Arthonia.

Though the genus comprises about 50 species, only a half dozen are known in North America, and but a single one exists in Minnesota.

Our plant is found only on trees. •

Type species *Arthothelium spectabile* Mass. loc. cit.

Arthothelium spectabile Mass. Ric. Lich. 54. f. 101. 1852.

Thallus mainly epiphloeodal and quite thick, whitish or grayish, sometimes in small patches, but more commonly covering large areas of the substratum, even 200 mm. or more in diameter, frequently bordered or dissected more or less by dark lines, smooth or roughened or even subareolate; apothecia difform, angulate, oblong or variously irregular, often immersed in the thallus, black, plane or convex; hypothecium brown or dark brown; hymenium brownish or brown; paraphyses much branched, hyaline or slightly brownish, the apices sometimes enlarged and more deeply colored; asci pyriform; spores ellipsoid, muriform, hyaline, or brownish, 8 in the asci, 28 to 38 μ long and 10 to 16 μ wide.

The plant has not been noted in the State, but is well known in northern Iowa and surely occurs in southern Minnesota. The species resembles *Arthonia radiata* externally and is easily overlooked. It is most common on hickory.

Known more or less from the Atlantic to the Pacific and from Florida as far north at least as Newfoundland. Also found in South America, Europe, and Asia.

Family LECANACTIDACEAE.

The family is a small one and represented in our flora by only two genera, each represented by a single species, and these both rare or seldom noted. One of the two genera, Lecanactis, is northern in distribution and the other is southern.

The members of the family all have a crustose thallus, frequently hypophloeodal and scarcely better developed than the thalli of the Graphidaceae. The algal symbiont is likewise Chroolepus, and the members of the family are all transitional forms, closely related to the Graphidaceae as to thallus structure and perhaps more closely to the Lecideaceae as to apothecial characters.

Both of the species assigned to the present family are sure to prove troublesome if found. The *Melaspilea* is likely not to be considered a lichen, as the thallus is frequently wanting. If taken for a lichen, it is likely to pass for a Lecidea or an Opegrapha. But the peculiar spores, consisting of two spheroidal cells should fix the plant. The Lecanactis is as likely to pass for a Bilimbia, but it may be known by its stronger, black, and persistent proper exciple.

MELASPILEA Nyl. Act. Soc. Linn. Bord. 21: 416. 1856.

The thallus is crustose, mainly hypophloeodal, so giving a smooth and widely extended crust, ashy in color, devoid of any differentiation into layers, the epiphloeodal portions at least quite commonly disappearing, in which case the thallus is said to be absent. The algal symbiont is Chroolepus-like.

The apothecia are rounded or oblong, in the former condition appearing lecideoid and in the latter more like Arthonia or Opegrapha. They are, however, superficial. The disk is black and flat or convex. The proper exciple is also black. The spores are 2-celled, commonly hyaline, and oblong, obtusely ellipsoid, or slipper-shaped.

Like Lecanactis, the present genus seems to be a transitional one with very similar relationships, the species having formerly been assigned to Lecidea, Opegrapha, Arthonia, etc.

A single species has been found in Minnesota.

Type species *Melaspilea arthonioides* (Fée) Nyl. loc. cit.

Melaspilea arthonioides (Fée) Nyl. Act. Soc. Linn. Bord. 21: 416. 1856.

Lecidea arthonioides Fée, Essai Crypt. 107. 1824.

Thallus as above; apothecia circular in outline or rarely somewhat oblong, scarcely reaching middle size, 0.4 to 1 mm. in diameter, adnate or at first more or less immersed, the disk black, plane or convex, the exciple black and prominent or rarely disappearing; hypothecium dark brown; hymenium pale below and brownish above; paraphyses simple or rarely branched, commonly enlarged and colored toward the apex; asci clavate; spores hyaline in ours at least, constricted at the septum so that each of the two cells frequently is spheroidal in form, 12 to 17 μ long and 6 to 8.5 μ wide.

Generally distributed in the State, but easily overlooked. On trees.

Elsewhere in North America in New England, Iowa, and Nebraska, the specimen from the latter State, determined by me for J. M. Bates, collected in 1898. Known also in Europe, Africa, and South America.

LECANACTIS Eschw. Syst. Lich. 14. 25. f. 7. 1824.

FIGURE 8.

The thallus is crustose, consisting of a continuous or scattered crust, sometimes chinky or verrucose, but scarcely reaching plainly areolate conditions, sometimes

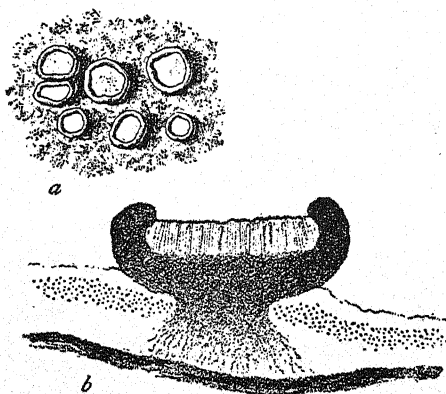


FIG. 8.—*Lecanactis abietina*. a, Plant; b, section of the thallus, showing the heavy, dark proper exciple and the hymenium within. Enlarged 40 diameters. From Reinke.

scurfy or mealy, without cellular cortex or medullary or algal layers. The algal symbiont is plainly *Chroolepus*, showing the cells linked together in the usual form, but the algae are peculiar in that they often show a reddish yellow color. The above characters of the thallus, especially the nature of the algal symbiont, are quite like those of the present suborder, but the apothecial characters are, in some of the species, more like those of the *Lecideaceae*.

The apothecia are commonly rounded, but sometimes oblong, and have a black proper exciple. The spores are 4 to several-celled, finger-shaped or fusiform, hyaline. The lecideoid nature of the apothecia has led some lichenists to place the

plants, or part of them, with the *Lecideaceae*, and surely there is ground for this view.

The present genus is, then, a transitional form, showing close relationship with two suborders of lichens, the rounded apothecia of some species being much like those of *Lecidea*, but the spores being more like those of the present suborder. However, the species having oblong apothecia are in this respect quite as near certain forms of *Opegrapha*.

A single species is known in Minnesota.

Type species *Lecanactis lobata* Eschw. loc. cit.

1. *Lecanactis premnea* (Ach.) Tuck. Proc. Amer. Acad. 12: 284. 1866.

Lecidea premnea Ach. Lich. Univ. 173. 1810.

Thallus a thin, continuous, smoothish or variously roughened, granulate or chinky crust, widely and irregularly spread over the substratum, greenish, sea-green, or ashy in color, sometimes surrounded by a blackening hypothallus; apothecia middle-sized, 0.75 to 1.5 mm. in diameter, rounded or becoming flexuous, sessile, the disk usually flat, black and commonly greenish-pruinose, the prominent exciple black and persistent; hypothecium dark brown; hymenium pale or brownish; paraphyses

simple or rarely branched, frequently enlarged and darkened toward the apex; asci cylindrico-clavate or cylindrical; spores fusiform-oblong and frequently curved, 4-celled, hyaline, 13 to 22 μ long and 3 to 5 μ wide.

Once collected along the northern boundary at Emo, Ontario. On cedars.

Elsewhere in North America in California, South Carolina, Alabama, and Ohio. Known also in Europe and Asia.

This was determined by T. Hedlund as *Lecanactis chloroconia* Tuck., and the plant was so recorded in the seventh preliminary report. Tuckerman reduced his plant to a subspecies of the above species, but the spore measurements in our plant seem to connect it with the type rather than the subspecies.

Family GYALECTACEAE.

Like the last family, the present one is represented in our flora by a few very rare species. The three genera to which these belong show some external resemblance in the commonly urceolate disk, the proper exciple, and the usually evanescent thalloid one. Indeed, *Gyalecta* and *Secoliga* are certainly closely related genera, as shown both in the thallus and in the apothecial characters. However, the stronger, dark proper exciple of *Conotrema* would seem to make its position in the family doubtful. But though the exciple sometimes nearly closes the disk, we can not think that the genus should be placed with the *Pyrenulaceae*. Yet it is readily admitted that the family, *Gyalectaceae*, is not a very natural one and that the genera might perhaps as well be parceled out to other families as is done by some authors.

The thallus is crustose in all of our plants, but minutely foliose forms occur elsewhere. It is usually thin and granular and sometimes evanescent, so that the plants appear much like closely related fungal *Discomycetes*. This is especially true in the first two genera. The algal symbiont is at least commonly *Cystococcus*.

The first two genera are also closely related as to spore characters, but here again *Conotrema* seems quite distinct.

The genus *Urceolaria*, which we have placed with the *Physciaceae*, is frequently regarded as a member of the present family.

While the family should, on the whole, doubtless stand next below the *Lecideaceae*, the poorly developed and usually evanescent thalloid veil or exciple seems to indicate a relationship with the *Lecanoraceae*. However, we must not lose sight of the fact that some of the *Lecideaceae* also show some hint of a thalloid exciple.

GYALECTA Ach. Lich. Univ. 30, 151. pl. 1. f. 7-9. 1810.

The thallus, in the American forms at least, is crustose and without a distinct cortex. The color is commonly sea green, varying toward greenish, ashy, or brownish. The structure is usually thin or very thin and variously smooth, chinky, granulate, leprose, or powdery, and frequently disappears. Some of the higher forms are said to possess upper and lower cortices, but we have not examined species having such layers. The algal symbionts are forms of *Cystococcus*, or according to some observers *Chrooclepus*.

The apothecia are commonly sessile and minute, though in a few species they may reach middle size. They are commonly more or less urceolate, and are uniformly surrounded by a somewhat colored proper exciple. Rarely a variously imperfect and more or less evanescent thalloid exciple surrounds the proper one. The hypothecium and the hymenium are commonly pale, and the paraphyses are usually simple, though compound ones may be found in some of the species. The asci vary from clavate to cylindrico-clavate. The spores are hyaline and 2-celled, though 4-celled species have commonly been admitted to the genus, and Tuckerman admitted even 10-celled forms, which we place under *Secoliga*.

The relations of the genus are very uncertain. The presence of the thalloid exciple in some species looks toward *Lecanora*; but such a structure also occurs in certain

Lecideas, and indeed the present genus seems much nearer to the closely related Biatorina. Possibly we should do better to follow some authors and place our species with the Biatorinas.

A single species has been met in the State. On wood and moss.

Type species *Gyalecta epulotica* Ach. loc. cit.

This is a Lecanora, and priority of paging would require that *Gyalecta* replace Lecanora. But again, *Parmelia* Ach. would take precedence over both *Gyalecta* and Lecanora. Again, it appears from work already done on typification of lichen genera that both Lecanora and *Parmelia* will have to give way to earlier names, if we follow rules of priority. This is but one example of the involved questions that arise regarding the validity of lichen genera.

1. *Gyalecta lutea* (Dicks.) Tuck. Gen. Lich. 131. 1872.

FIGURE 9.

Lichen luteus Dicks. Pl. Crypt. Brit. 1: 11. pl. 2. f. 6. 1785.

Thallus a thin, smoothish or minutely roughened crust, variously spread over the substratum as a continuous or more or less broken layer, greenish and varying toward ashy (the latter perhaps the more typical color when free algæ are not scattered over the surface), sometimes becoming very inconspicuous or disappearing; apothecia minute (in ours at least), 0.2 to 0.4 mm. in diameter, sessile, urceolate or becoming flattish, the disk pale yellowish or flesh-colored, the proper exciple commonly lighter

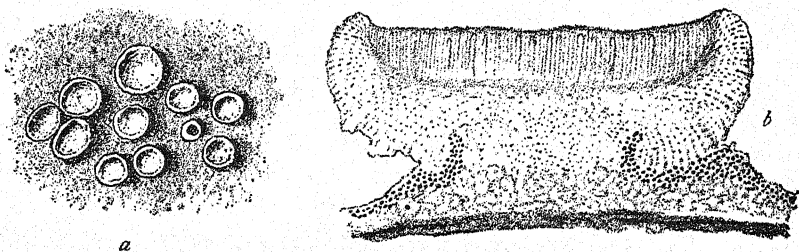


FIG. 9.—*Gyalecta lutea*. a, Several apothecia; b, section of an apothecium, showing the exciple, the hypotheccium, and the hymenium. a, Enlarged 6 diameters; b, 90 diameters. From Reinke.

colored and sometimes obscurely striate, a very thin thalloid exciple also rarely to be distinguished in sections; hypotheccium and hymenium pale, or the latter yellowish above; paraphyses commonly simple, sometimes slightly thickened toward the apex, asci cylindrico-clavate; spores fusiform-ellipsoid, 6 to 11 μ long and 3 to 4 μ wide.

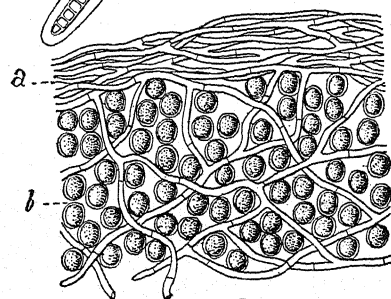
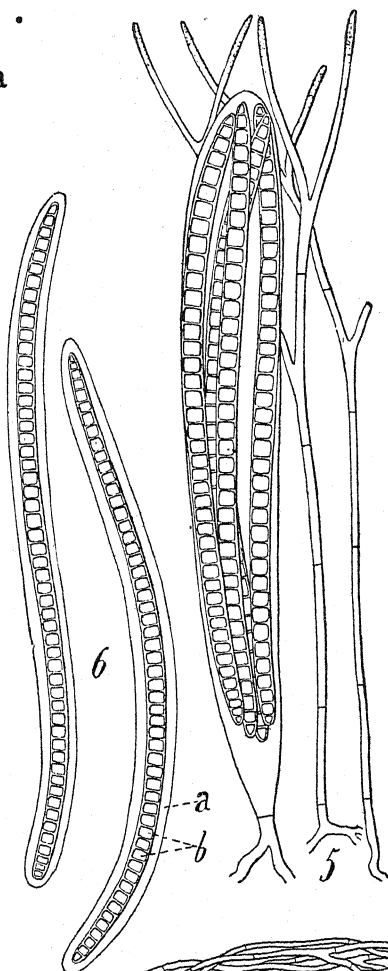
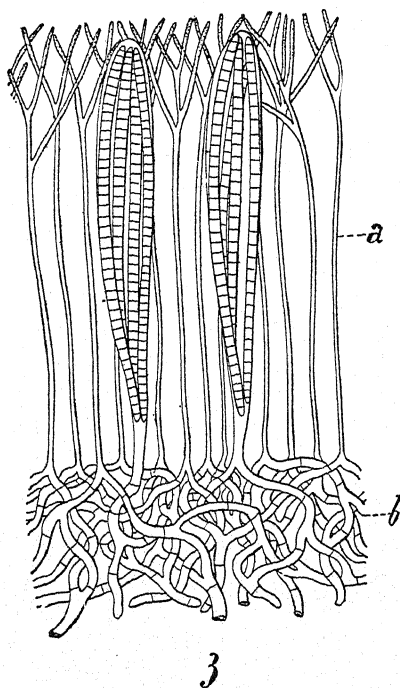
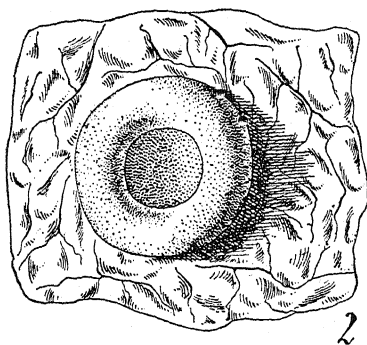
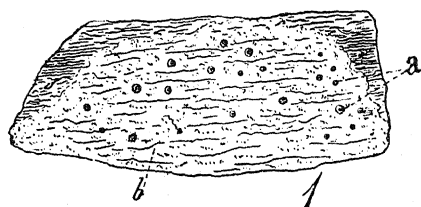
Collected on the islands belonging to the United States in Lake of the Woods, and at Emo on the northern boundary. On wood and mosses.

Elsewhere in North America in New England, New York, Florida, Alabama, Illinois, Iowa, Nebraska, Ontario, and Manitoba. Known also in all of the grand divisions.

SECOLIGA Norm. Nyt. Mag. Naturv. 7: 230. pl. 1. f. 9 b, 10 c, d; pl. 2. f. 24 a. 1853.

The thallus is essentially like that of the *Gyalectas*, crustose and without a distinct cortex. In color and thickness, as well as in general appearance, the resemblance is quite as great.

The apothecia are also commonly minute and sessile. They are usually more or less concave or even urceolate, and the surrounding proper exciple is more or less colored. The thalloid exciple is scarcely ever seen, if present at all, and was not observed in our species. The hypotheccium and the hymenium are pale, or the latter slightly colored above. The paraphyses were simple in the material examined, and the asci were cylindrico-clavate. The spores are hyaline and 4-celled, or in some of the species they may pass from 4 to 10-celled or muriform conditions.



CONOTREMA URCEOLATUM (ACH.) TUCK.

The relationship of the present genus is quite as obscure as that of *Gyalecta*, but after *Gyalecta* the genus is doubtless most closely related to *Bilimbia*.

Two species have been met in the State. On trees.

Type species *Secoliga cupularis* (Ehrh.) Norm. loc. cit.

KEY TO THE SPECIES.

- On trees; exciple entire.....1. *S. fagicola*.
On rocks; exciple radiately striate.....2. *S. cupularis*.

1. *Secoliga fagicola* Hepp.; Koerb. Par. Lich. 112. 1865.

Thallus very thin and somewhat chinky or scaly-roughened, pale greenish or becoming brownish, irregularly spread over the substratum as a continuous or more or less broken layer, or sometimes disappearing; apothecia very minute, 0.15 to 0.3 mm. in diameter, sessile, the disk commonly concave and flesh-colored, or becoming rusty-red and blackening, the proper exciple entire and of the same color as the disk (no evidence of a thalloid exciple seen); hypothecium and hymenium pale, or the latter sometimes darker above; paraphyses slender and commonly simple; asci clavate; spores fusiform or pointed-fusiform, 4 to 10-celled, 15 to 40 μ long and 3 to 6 μ wide, 8 to 20 in each ascus.

Collected along the shores of Snowbank Lake. On trees.

Elsewhere in North America in Massachusetts. Known also in Europe.

Gyalecta fagicola of the preliminary reports.

2. *Secoliga cupularis* (Ehrh.) Norm. Nyt. Mag. Naturv. 7: 230. pl. 1. f. 10 c. 1853.

Lichen cupularis Ehrh. Beitr. Naturk. 4: 45. 1789.

Thallus thin, somewhat scurfy or smoother and chinky, greenish ash-colored or becoming darker, irregularly and widely spread over the substratum as a continuous or more or less broken layer; apothecia small or minute, 0.25 to 0.5 mm. in diameter, adnate or rarely sessile, urceolate or more open and shallower, the disk brick-red or paler, the proper exciple whitish and radiately striate or becoming smooth; hymenium and hypothecium pale; paraphyses distinct, simple and pale throughout; asci cylindrical or cylindric-clavate; spores ellipsoid, muriformly several-celled, 13 to 17 μ long and 6 to 9 μ wide, 8 in each ascus.

On shaded rocks at Pork Bay. Not previously reported from Minnesota.

Elsewhere in North America from several States bordering on the Atlantic. Known also in Europe and New Zealand.

CONOTREMA Tuck. Syn. Lich. N. E. 86. 1848.

PLATE 3.

The crustose thallus is quite rudimentary in structure and without distinct layers. There is, however, a greater or less development of superficial hyphæ running for the most part in a horizontal direction and forming a protective and poorly pseudocortical layer. The structure is mostly epiphloeodal, strictly crustose, thin, smooth or somewhat roughened. Cystococcus is the algal symbiont. Hyphal rhizoids form the attaching organs.

The apothecia are small and more or less immersed in the thallus and partly hypophloeodal. However, the thallus partly disappears with age and the larger apothecia appear to be sessile. There is a dark proper exciple and in the early development, at least, this is surrounded by a thin thalloid one. The hypothecium and the hymenium are pale. The asci are cylindrical. The spores are also cylindrical, many-celled, and hyaline. The paraphyses are commonly branched toward the apex.

The genus is represented by a single species and its relationships are by no means certain. The so-called apothecium is perhaps as nearly a perithecium. It is deeply

urceolate, and the disk tends toward closed conditions like those encountered in the perithecia of *Verrucaria* and allied genera. The presence of *Cystococcus* instead of *Chroolepus* looks toward the present family, to which the present genus is doubtless more closely related. The spores are, however, quite different.

The single species has been met once in the State. On trees.

Type species *Conotrema urceolatum* (Ach.) Tuck. loc. cit.

EXPLANATION OF PLATE 3.—Fig. 1, *a*, an apothecium; *b*, thallus, natural size. Fig. 2, an apothecium and a portion of the thallus. Fig. 3, section of an apothecium; *a*, the hymenium; *b*, the hypothecium. Fig. 4, a section of the thallus; *a*, the pseudocortex of entangled hyphae; *b*, the layer of algal cells and fungal hyphae below. Fig. 5, paraphyses and an ascus. Fig. 6, free compound spores; *a*, the exosporium; *b*, the cell lumina. Fig. 1, natural size; fig. 2, enlarged about 20 diameters; figs. 3, 4, enlarged about 400 diameters; figs. 5, 6, enlarged 650 diameters. From Schneider.

Conotrema urceolatum (Ach.) Tuck. Syn. Lich. N. E. 86. 1848.

PLATE 3.

Lecidea urceolata Ach. Syn. Meth. Lich. 27. 1814.

Thallus crustose, thin, and smooth, or becoming somewhat chinky, scurfy, or more or less distinctly areolate, ashy-whitish, sometimes partly disappearing, a layer of mostly horizontally interwoven hyphae forming somewhat of a protective pseudocortex, somewhat orbicular and 15 to 65 mm. across, or irregular and more widely spread over the substratum; apothecia small or subminute, 0.4 to 0.75 mm. in diameter, partly hypophloeodal, but extending above the thin thallus and usually appearing externally to be adnate or sessile, deeply urceolate and commonly more or less white-pruinose within, the exciple proper, blackish, at first surrounded by a thin thalloid one; hypothecium and hymenium pale, or the latter sometimes darker above; paraphyses more or less branched toward the apex, there also slightly thickened and darker; asci cylindrical; spores cylindrical, 100 to 160 μ long and 3 to 4.5 μ wide, 30 to 40-celled.

Collected at Hibbing in the northern part of the State, by Anna M. Kimball. On trees.

Throughout the eastern half of North America, in mountains toward the south. Known also in South America and Europe.

Family LECIDEACEAE.

Unlike the last two families, the present is one of the largest in our Minnesota lichen flora, including many species and some of our best-known lichens. Notwithstanding the large number of genera included, there is considerable similarity in apothecial structure throughout. Indeed, taking only this apothecial structure into account, the genera of the family would seem to be closely related, exhibiting various conditions in the evolution of a strong and persistent proper exciple. Doubtless some members of the Patellariaceae are the fungal ancestors of all the members of the present lichen family, but when we consider the great range of difference in the spore characters in the Lecideaceae, including, indeed, the extremes in spore evolution, viz, the simple hyaline spore and the brown muriform spore, we can only suppose that the various genera must have arisen from quite different fungal ancestors.

The thallus is crustose in the family as limited in this volume, and varies from inconspicuous and evanescent leprose or granular conditions to verrucose, areolate, or even subsquamulose states. The apothecia are commonly rounded, and are so much alike in the different genera that one often can not be certain even of the genus in the field. However, the darker apothecia, as a rule, belong to the genera having the stronger exciples. Some suggestion of a thalloid exciple may be made out, outside the proper one, in a few species. The algal symbiont is *Cystococcus*, except perhaps in some *Biatorinas*.

The family is closely related to the Baeomycetaceae, differing mainly in the absence of a stipe, and also certain transitional forms with some showing of thalloid exciple seem to look toward the Lecanoraceae. Finally, the genera having brown

spores are doubtless somewhat closely related with the Physciaceae, especially *Buellia* with *Rinodina* and *Rhizocarpon* with *Urceolaria*.

BIATORELLA De Not. Giorn. Bot. Ital. 21: 192. 1846.

The thallus is crustose and commonly granulose, sometimes verrucose or subareolate, and is on the whole much less developed than in *Lecidea*. Indeed, it is quite commonly evanescent or so rudimentary as to appear only with the most careful examination with lens or even in section with microscope. Of course there is no cortex, nor can algal and medullary layers be distinguished. The thin and rudimentary structure lies mainly above the substratum to which it is attached by hyphal rhizoids. The algal cells seem to be *Cystococcus*.

The apothecia are commonly minute or at least small, though they may reach middle size in one of our species. The exciple is of the lecideoid type, composed of closely interwoven hyphae, and is frequently evanescent. It is usually light in color, but may be darker and firm as in the higher members of *Lecidea*. The disk may be flat or convex and in the latter condition frequently overgrows the exciple. The exciple, however, may be persistent and raised somewhat above the border of the disk. Both hypothecium and hymenium vary from pale to brown. The spores are minute and numerous in the asci, though in one species not represented in our flora there are only 12 to 18 spores in each ascus. They are simple and are globular to oblong or ellipsoid in form.

The present genus is closely related to *Lecidea*, though possibly nearer *Bacidia* or *Bilimbia*, as the minute and numerous spores may have arisen from a breaking up of the long compound spores of members of these genera to form the minute and more numerous ones of the present genus. Tuckerman has included in *Lecidea* and *Heterothecium* forms having minute and numerous spores. We do not encounter these among our Minnesota species, but it is evident that they should all be brought together into one genus, or possibly two closely related genera. We have also transferred *Lecanora privigna* to the present genus under the older synonym *Biatorella simplex*.

The genus has four species and subspecies in Minnesota. On trees and rocks.

Type species *Biatorella roussellii* (Dur. & Mont.) De Not. loc. cit.

KEY TO THE SPECIES.

- Spores spherical..... 1. *B. moriformis*.
- Spores oblong-ellipsoid.
 - Apothecia pruinose..... 2a. *B. simplex pruinosa*.
 - Apothecia not pruinose.
 - Apothecia small or minute, adnate..... 2. *B. simplex*.
 - Apothecia middle-sized, loosely sessile or sub-stipitate..... 3. *B. clavus*.

1. *Biatorella moriformis* (Ach.) Th. Fr. Lich. Scand. 2: 401. 1874.

Arthonia moriformis Ach. Syn. Meth. Lich. 5. 1814.

Thallus composed of very minute granules, these commonly compacted into a thin, smooth, or more or less leprose or chinky crust, sea-green or more commonly whitish or rarely brownish, widely spread over the substratum or disappearing entirely; apothecia small or minute, 0.2 to 4 mm. in diameter, adnate, flat to slightly convex, pale brownish to brown and finally black; exciple evanescent or entirely absent; hypothecium pale; hymenium pale throughout or brownish above; paraphyses commonly simple and somewhat enlarged and brownish above, somewhat gelatinized and indistinct; asci clavate or ventricose; spores spherical, very minute, 1.5 to 2.5 μ in diameter, numerous in the asci.

Collected at Warroad and Tower. On cedars. A rare lichen in the State and also for North America.

Known elsewhere in North America in Massachusetts and Washington, and at Lake Manitoba and Lake Winnipegosis. Known also in Europe.

Biatora moriformis of the preliminary reports.

2. *Biatorella simplex* (Dav.) Br. & Rostr. Bot. Tidssk. 3: 241. 1869.

Lichen simplex Dav. Trans. Linn. Soc. Lond. 2: 283. pl. 28. f. 2. 1794.

Thallus deficient and seldom seen; apothecia small or minute, 0.2 to 0.8 mm. in diameter, adnate, scattered or crowded into dense clumps, rounded or becoming variously irregular, the disk dark red or black, the thin exciple persistent, raised and black; hypothecium cloudy or brownish; hymenium pale; paraphyses slender, simple or rarely branched, frequently somewhat thickened and brownish toward the apex; asci cylindrical or cylindrico-clavate; spores oblong-ellipsoid, minute, 3 to 5 μ long and 1 to 1.5 μ wide, very numerous in the asci.

Found in the southern half of the State wherever limestone occurs and as far to the northwest as Leaf Hills and Battle Lake. On limestones.

Widely distributed in the United States and as far north as Newfoundland. Known in all of the grand divisions except South America.

Lecanora privigna is the synonym of the preliminary reports.

2a. *Biatorella simplex pruinosa* (J. E. Smith) Fink.

Lichen pruinus J. E. Smith in Sowerby, Engl. Bot. 32: pl. 2244. 1811.

Thallus thin and perhaps as deficient as in the last; apothecia more closely appressed or even more or less immersed in the substratum, the disk more or less pruinose, becoming rather larger, reaching 1 millimeter or more in diameter, otherwise externally and internally as the above.

Sometimes considered a distinct species, but certainly connected by intermediate forms with the *B. simplex*.

Occurring with the type and on the same substrata.

North American distribution about as of the last, but not found quite so far north.

Found also in Europe and Africa.

Lecanora privigna pruinosa of the preliminary reports.

3. *Biatorella clavus* (Lam. & DC.) Th. Fr. Lich. Scand. 2: 409. 1874.

Patellaria clavus Lam. & DC. Fl. Fr. ed. 3. 2: 348. 1805.

Thallus as in the last, but perhaps more commonly present though indistinct; apothecia middle-sized or larger, 0.7 to 2 mm. in diameter, rather loosely sessile or substipitate, scattered or somewhat clustered, rounded or becoming wavy or variously irregular, the disk dark red or black, concave or becoming flat or even somewhat convex, the exciple thick, chinky and raised, or finally disappearing; hypothecium brown or blackening; hymenium pale or brownish; paraphyses simple or rarely branched, scarcely so slender as in the last, commonly enlarged and brownish or bluish toward the apex; asci cylindrico-clavate or ventricose; spores oblong-ellipsoid, minute, 4 to 6.5 μ long and 2 μ wide, thus on the whole larger than those of the last.

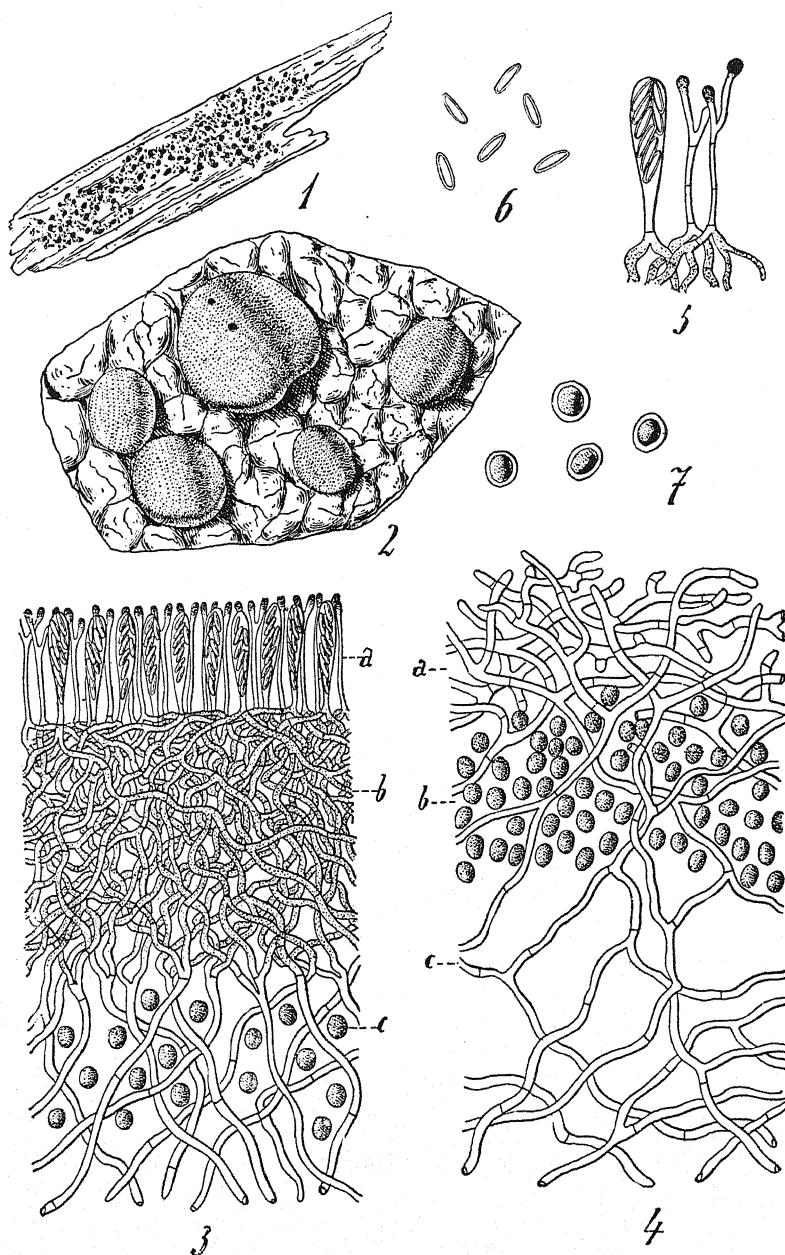
Sometimes considered a subspecies of the last, but ours seems distinct enough, as does all other material at hand.

The plant was collected on the sandstone at MacGregor, Iowa, and no doubt occurs on the same rocks along the Mississippi River in Minnesota.

Elsewhere in North America known from New England, West Virginia, Georgia, Kansas, and California. Known also in Europe.



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LECIDEA MELANCHEIMA TUCK.

LECIDEA Ach. Meth. Lich. xxx, 32. pl. 2. f. 1, 2. 1803.

PLATE 4.

The thallus is crustose and variously granulose, verrucose, or areolate. Lichens with squamulose thalli have been admitted to the genus by many authors, but following our disposition of the poorly defined group *Biatora*, as admitted by Tuckerman, we have separated these. There are no definite layers of the thallus, except possibly in a very few species having rather thick thalli, and even in these there is no definite cortex. As is usual in such rudimentary thalli, hyphal rhizoids penetrate the substratum and serve as attaching organs. The algal symbionts are the common *Cystococcus*. The thallus is frequently evanescent.

The apothecia are small, or rarely reach middle size. They are commonly adnate or immersed, though sessile apothecia occur in some of the species. The disk varies from pale to black and is flat or convex. The proper exciple and the hypothecium vary from pale to dark brown in sections, the former often being black macroscopically. The spores are simple, hyaline, and usually oblong or ellipsoid, though some species have spores in part 2-celled.

The genus as above limited is closely related to *Megalospora*, and contains but a small proportion of the species placed in it by some lichenists. *Psora* has been excluded because of difference in thallus structure and *Biatorina*, *Bilimbia*, *Bacidia*, and *Biatorella* because of diversity of spore structure. The *Lecideas* represent a different line of evolution and are doubtless nearer the *Megalosporas* than are the *Bilimbias* and *Bacidias*.

Thirty-four species and subspecies have been found in the State. On trees, rocks, earth, old wood, and mosses.

Type species *Lecidea tigillaris* Ach. loc. cit. This plant is our *Acolium tigillare* (Ach.) De Not. Thus it would seem that *Lecidea* must be replaced by another name after the lichen genera have all been typified, and the substitute will probably be *Parmelia*.

EXPLANATION OF PLATE 4.—Fig. 1, plant. Fig. 2, apothecia and a portion of the thallus. Fig. 3, a section of an apothecium and part of the thallus; *a*, the hymenium; *b*, the hypothecium; *c*, the algal layer. Fig. 4, a section of the thallus; *a*, the pseudocortex of entangled hyphae; *b*, the algal layers; *c*, the medullary layer. Fig. 5, paraphyses and an ascus. Fig. 6, free spores. Fig. 7, algal cells. Fig. 1, natural size; fig. 2, enlarged about 10 diameters; figs. 3, 4, enlarged 425 diameters; figs. 5, 6, 7, enlarged 650 diameters. From Schneider.

KEY TO THE SPECIES.

Section I. Exciple and hypothecium softish and usually light-colored (*Biatora*).
Parasitic on other lichens, no thallus of its own distinguishable..... 18. *L. oxyspora*.

Not parasitic on other lichens.

Thallus sea-green to ashy.

Thallus areolate.

Apothecia small or minute, disk pale flesh-color to black..... 1. *L. coarctata*.

Apothecia larger; disk usually black..... 2. *L. brujeriana*.

Thallus granular, or if areolate tardily so.

Thallus tardily areolate or subareolate.

Margin of the apothecium becoming flexuous; disk black and flat..... 4. *L. flexuosa*.

Margin of the apothecium not flexuous.

Disk flattish to strongly convex, pale brownish to black..... 10. *L. turgidula*.

- Disk flat or rarely somewhat convex,
dark brown to black..... 11. *L. panaeola*.
- Thallus granular, but never areolate or subareolate.
Thallus becoming chinky.
Disk flat or somewhat convex, pale to
reddish brown or black..... 6. *L. mutabilis*.
Disk becoming very convex, pale yellowish to reddish brown or black... 7. *L. vernalis*.
Thallus not chinky.
Granules very minute; apothecia
black..... 5. *L. viridescens*.
Granules larger.
Granules large; apothecia middle-sized, from flesh-color to olive-
ceous and black..... 3. *L. granulosa*.
Granules middle-sized; apothecia
small, rusty-brown, passing
through sanguineous to black.. 8. *L. sanguineoatra*.
- Thallus not usually sea-green nor ashy.
Thallus usually brown or brownish.
Thallus forming an inconspicuous, evanescent
crust; apothecia small or minute, pale flesh
color and darkening..... 9. *L. carnulenta*.
Thallus plainly granular, persistent.
Thallus often tardily subareolate; apothecia
small or minute, brown to black.... 13. *L. myriocarpoides*.
Thallus never becoming subareolate.
Thallus thicker, greenish-olivaceous
to rusty-brown or darker; apothecia
small or minute, brown or brownish
black 12. *L. uliginosa*.
Thallus thinner; apothecia and spores
smaller than in the above..... 12a. *L. uliginosa fuliginosa*.
- Thallus greenish or yellowish.
Thallus granular, tardily becoming chinky.
Apothecia commonly flat, or becoming
convex, very minute, pale yellowish to
brown or black..... 14. *L. varians*.
Apothecia commonly convex, twice as
large as in the last, brown or black..... 15. *L. querneae*.
Thallus granular, not becoming chinky.
Apothecia olivaceous or black, minute... 16. *L. flavidolivens*.
Apothecia pale lemon to brownish, small
or minute..... 17. *L. lucida*.
- Section II. Exciple and hypothecium horny, usually dark-colored (Eulecidea).
On rocks.
Thallus whitish or whitish ashy, becoming chinky
and areolate; apothecia immersed or adnate, reaching
middle size, black..... 24. *L. speirea*.
Thallus ashy, sea-green, or rarely olivaceous.
Thallus minutely scurfy-granular; apothecia minute,
black..... 26. *L. cyrtidia*.

Thallus not plainly granular.

Thallus becoming more or less distinctly areolate.

Apothecia usually immersed.

Hypothecium pale..... 20. *L. cyanea*.

Hypothecium dark.

Thallus widely spread; apothecia

small..... 19. *L. lapicida*.^a

Thallus usually covering quite

limited rounded or irregular

areas; apothecia middle-sized. 23. *L. lactea*.

Apothecia not usually immersed.

Apothecia adnate or somewhat im-

mersed, commonly somewhat

pruinose..... 25. *L. albocaerulescens*.

Apothecia sessile or adnate, rarely

somewhat pruinose..... 27. *L. platycarpa*.

Thallus becoming chinky but not areolate,
rarely subareolate.

Hypothecium pale; apothecia small,

blackish, rarely pruinose..... 21. *L. lithophila*.

Hypothecium dark.

Disk flat, with persistent exciple,

black..... 22. *L. contigua*.

Disk convex, exciple disappearing.. 22a. *L. contigua convexella*.

On trees or old wood (rarely on rocks).

Thallus rather thick, rough and verrucose; apothecia

middle-sized, adnate, very black..... 29. *L. melancheima*.

Thallus thinner, smooth or becoming areolate or verrucose.

Thallus pale yellowish, verrucose..... 28a. *L. enteroleuca theioplaca*.

Thallus sea-green, ashy, or whitish.

Thallus becoming chinky, areolate, or verrucose.

Thallus becoming chinky or areolate..... 28. *L. enteroleuca*.

Thallus becoming verrucose or verrucose-areolate.

Thallus rather thick at first but often

disappearing..... 28d. *L. enteroleuca pilularis*.

Thallus at first thin, becoming

thicker..... 28b. *L. enteroleuca achrista*.

Thallus not usually becoming areolate or verrucose.

Thallus thin and smoothish, variegated

by black lines..... 28c. *L. enteroleuca flavida*.

Thallus thin and smoothish, not varie-

gated by black lines..... 28e. *L. enteroleuca ambigua*.

^aSee also 19a. *L. lapicida oxydata*.

1. *Lecidea coarctata* (J. E. Smith) Nyl. Act. Soc. Linn. Bord. 21: 358. 1856.

Lichen coarctatus J. E. Smith in Sowerby, Engl. Bot. 8: pl. 534. 1799.

Thallus composed of minute, scattered or clustered, rounded, angular or minutely and irregularly crenate, sea-green, brownish, or more commonly ashy, sometimes squamaceous areoles 0.3 to 0.5 mm. in diameter, sometimes even passing into an areolate or subcontinuous and chinky crust; apothecia adnate, minute or small, 0.2 to 0.4 mm. in diameter; the disk commonly concave or flat and frequently difform, from pale flesh-color to black, sometimes having more or less of a thalloid exciple, or more commonly this disappearing and the structure becoming truly biatoroid; hypothecium pale to brownish; hymenium pale to yellowish or brownish; paraphyses slender, frequently branched, commonly thickened and darker toward the apex; asci clavate; spores ellipsoid or ovoid, 13 to 23 μ long and 7 to 10 μ wide.

On account of the sometimes present thalloid exciple the plant has often been referred to *Lecanora*, but its affinities on the whole are rather with the present genus. The plant is quite variable.

Collected at such remotely separate localities as Beaver Bay and Mankato and no doubt widely distributed in the State. On sandstone and igneous rocks. The plants from Mankato show the thalloid accessory exciple fairly well.

The plant is widely distributed in North America. Known in all of the grand divisions except Australia.

Biatora coarctata of the preliminary reports.

2. *Lecidea brujeriana* (Schaer.) Leight. Brit. Lich. 281. 1871.

Lecanora coarctata brujeriana Schaer. Enum. Lich. Eur. 77. 1850.

Thallus composed of minute verrucæ or granules or sometimes of larger areoles, scattered or clustered in a continuous or areolate crust, this quite thick and prominent or thin and finally disappearing, the color much as in the last, the structure on the whole coarser; apothecia adnate, becoming larger than in the last and in some forms here admitted even reaching 1 millimeter in diameter, concave, flat or convex, frequently clustered, the disk usually black, frequently bordered by a stout biatoroid exciple of the same color, but never with a thalloid exciple; hypothecium and hymenium more or less brownish; paraphyses simple or branched, enlarged and dark toward the tips; asci clavate, the apical wall thickened; spores ovoid-ellipsoid, 12 to 21 μ long and 6 to 10 μ wide. Regarded by Tuckerman as a subspecies of the last, but quite distinct.

Our plant as reported from Taylors Falls seems nearer the last, nor is our material from the only other known Minnesota locality, Mankato, as well defined as the rather smaller plant collected at La Crosse, Wisconsin, by L. H. Pammel. Both the last and all the Minnesota material on sandstone.

Tuckerman reports the species from sandstone in South Carolina. Known also in Europe.

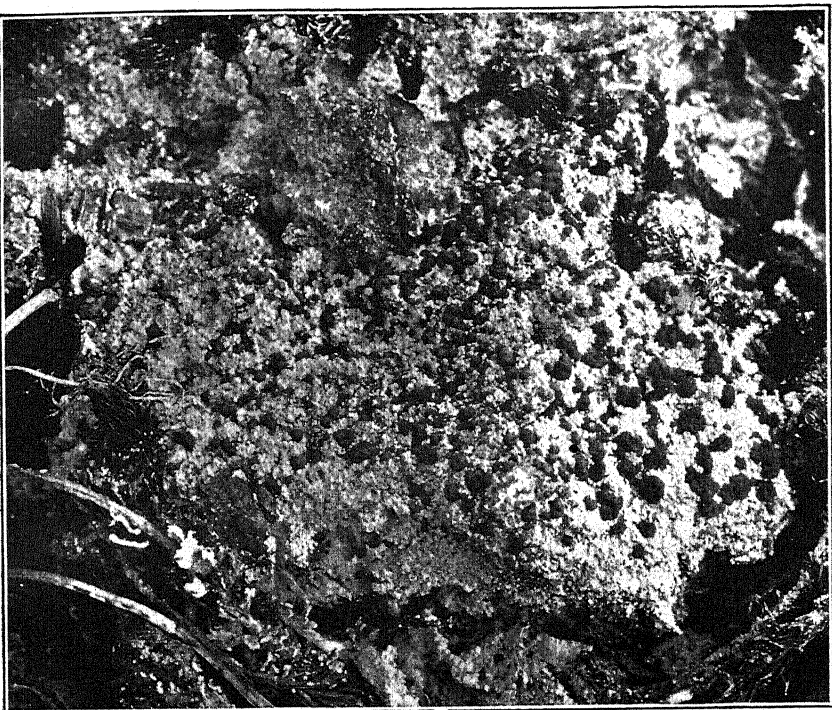
Biatora coarctata brujeriana of the preliminary reports.

3. *Lecidea granulosa* (Hoffm.) Ach. Meth. Lich. 65. 1803.

PLATE 5, A

Verrucaria granulosa Hoffm. Descr. Pl. Crypt. 2: 21. pl. 30. f. 3. 1794.

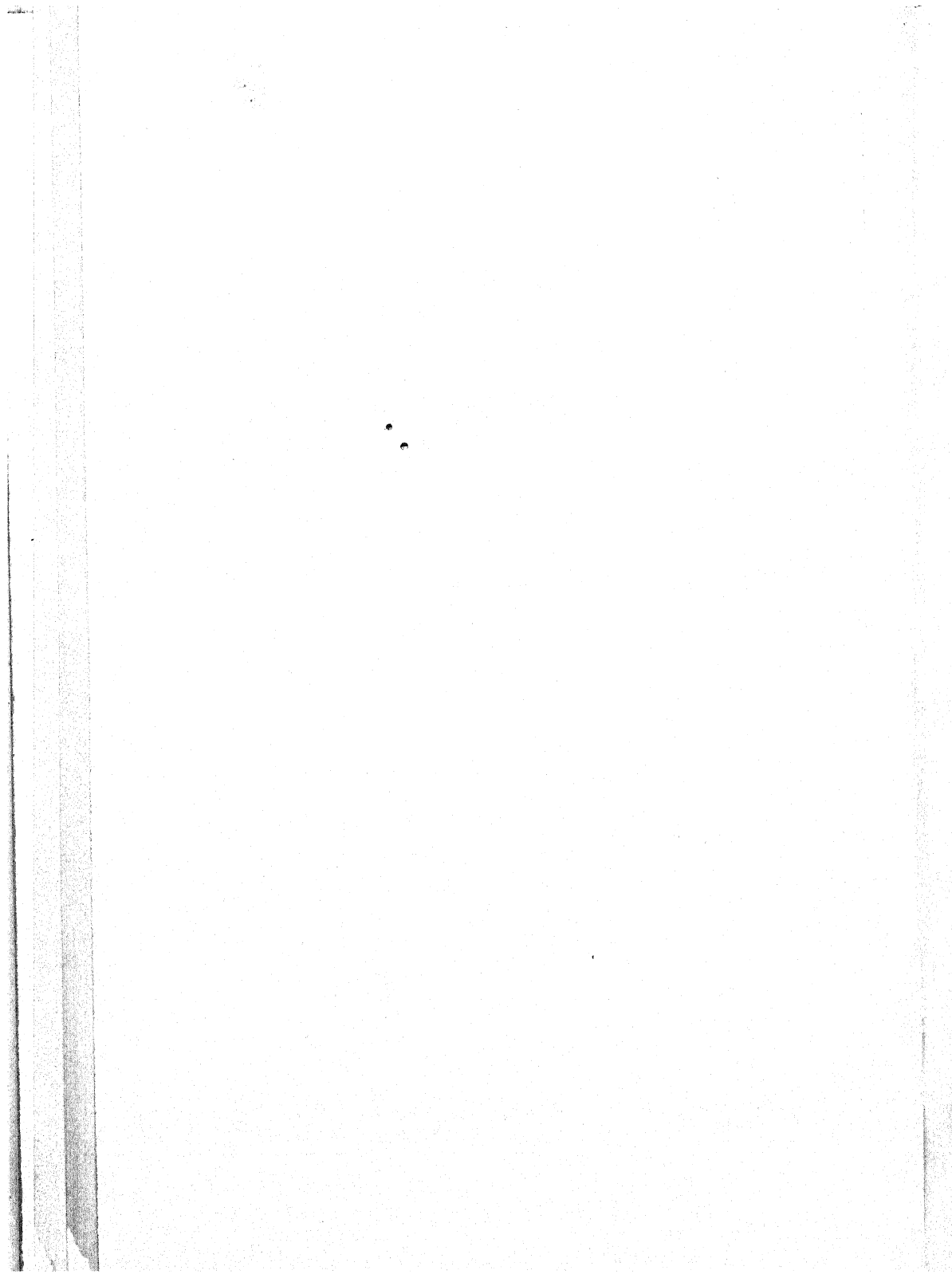
Thallus composed of hemispherical or irregular and sublobate, commonly densely aggregated and subimbricate, ashy or sea-green smooth granules, these 0.2 to 0.5 mm. in diameter, frequently bursting into greenish sorediate heaps, for the most part widely spread over the substratum with clusters of apothecia here and there; the whole structure verrucose and, in the better developed conditions, more or less of a pseudo-cortex of gelatinized hyphæ to be made out above, the thallus being thus more highly developed than in any other of our members of the genus; apothecia reaching middle size, 0.3 to 1.5 or even 2 mm. in diameter, adnate, from flesh-colored to olivaceous and black, with an elevated and frequently lighter-colored margin, this commonly disappearing, leaving the disk convex and the apothecia as a whole irregular and fre-



A. *LECIDEA GRANULOSA* (HOFFM.) ACH.



B. *BACIDIA RUBELLA* (HOFFM.) MASS.



quently conglomerate; hypothecium pale brown; hymenium pale brownish or darker above; paraphyses rarely branched or enlarged toward the apex, frequently more or less gelatinized and coherent; asci cylindrico-clavate; spores ovoid-ellipsoid, 9 to 16 μ long and 4.5 to 7 μ wide.

The plant has been collected only on Blueberry Island in Lake of the Woods, at Koochiching and at Grand Marais, but doubtless occurs in southern Minnesota as it has been collected at McGregor, in Iowa, a short distance from the Minnesota line. On earth and on cedars in swamps.

Widely distributed in the northern United States, especially in mountains, and northward to arctic America. Known also in Europe.

Biatora granulosa of the preliminary reports.

EXPLANATION OF PLATE 5.—A, Plants of *Lecidea granulosa* on earth, showing the conspicuous apothecia and the granulose thallus. B, Plants of *Bacidia rubella* on smooth bark, showing the apothecia. A and B enlarged about 1½ diameters.

4. *Lecidea flexuosa* (Fr.) Nyl. Act. Soc. Linn. Bord. 21: 356. 1856.

Biatora flexuosa Fr. Vet. Akad. Handl. 1822: 267. 1822.*

Thallus composed of rather flattened or rugose granules, these smaller than those of the last, scattered or clustered and not infrequently forming an areolate crust, spreading widely over the substratum, sea-green varying to ashy, sometimes bursting into sorediate heaps; apothecia adnate, small or minute, 0.2 to 0.4 mm. in diameter, the thin livid or darker margin becoming very flexuous, the disk black and flat; hypothecium brown or brownish, the exciple commonly darker in section; hymenium pale brownish; paraphyses commonly simple, but somewhat gelatinized and indistinct in the material examined; asci cylindrico-clavate; spores oblong-ellipsoid, 7 to 10 μ long and 3 to 5 μ wide.

Collected at Granite Falls and at Harding, the material from the latter place being especially fine. On old wood.

Throughout the eastern United States and northward to Newfoundland. Known also in Europe and Africa.

Biatora flexuosa of the preliminary reports.

5. *Lecidea viridescens* (Schrad.) Ach. Meth. Lich. 62. 1803.

Lichen viridescens Schrad. Spic. Fl. Germ. 88. 1794.

Thallus composed of very minute, smooth or deliquescent and powdery granules, these 0.1 to 0.2 mm. in diameter and frequently widely spread over the substratum in a thin layer, ashy to greenish; apothecia frequently clustered and conglomerate, adnate, in ours small or minute, 0.2 to 0.4 mm. in diameter; margin of exciple of same color as in the last, but thinner and disappearing early as the black disk becomes convex; hypothecium pale brownish or brown; hymenium brownish or purplish; paraphyses rarely branched, thickened and darker toward the apex; asci clavate; spores oblong or ovoid, 9 to 13 μ long and 4 to 5.5 μ wide.

Collected in the Misquah Hills and at Bemidji. On old wood. Doubtless to be found at other places in the northern portion of the State.

Known elsewhere in North America in New Jersey, New England, Alaska, and on Cape Breton Island. Found also in Europe.

Biatora viridescens of the preliminary reports.

6. *Lecidea mutabilis* Fée, Mém. Mus. Hist. Nat. Strasb. 2^E: 105. 1835.

Thallus composed of small, closely contiguous granules, usually running together into a continuous and more or less chinky ashy-gray crust, in ours rather thin and covering somewhat rounded areas of substratum from 10 to 35 mm. in diameter, the chinky crust possibly sometimes becoming subareolate; apothecia small, or in ours even minute, 0.2 to 0.5 mm. in diameter, adnate, the disk flat or becoming convex,

pale to reddish brown, or in ours black, the thin exciple soon disappearing; hypothecium pale or yellowish; hymenium pale; paraphyses simple or rarely branched, seldom thickened or much darkened toward the apex; asci clavate or cylindrico-clavate; spores ovoid-ellipsoid, 13 to 16 μ long and 7 to 9 μ wide.

The plant referred to this species was collected at Warroad. On trees.

Elsewhere known in the United States from the extreme southern States. It continues southward through Mexico into South America. Known also in Europe and Africa.

Biatora mutabilis of the preliminary reports.

7. *Lecidea vernalis* (L.) Ach. Meth. Lich. 68. 1803.

Lichen vernalis L. Syst. Nat. ed. 12. 234. 1768.

Thallus composed of very minute, scattered or contiguous, ashy to sea-green, irregular or hemispherical granules, these about 0.1 to 0.2 mm. in diameter, commonly widely spread over the substratum as a more or less continuous layer, or when on wood sometimes becoming compacted into a smoother, less granular, chinky crust, usually quite thin; apothecia adnate, small, commonly 0.15 to 0.85 mm. in diameter, becoming very convex and the exciple disappearing, often clustered and even conglomerate, the disk from pale yellowish to reddish brown and even blackening; hypothecium pale brownish to brown; hymenium pale brownish; paraphyses simple or branched toward the apex, pale or brownish-tinged, the apex sometimes thickened; asci clavate; spores oblong-ellipsoid, 12 to 17 μ long and 4 to 6 μ wide, sometimes 2-celled.

Generally distributed over the northern portion of the State. On mosses, especially at the bases of trees, and also rarely on wood.

Distributed throughout the northern United States and northward to arctic America. Known in all of the grand divisions.

Biatora vernalis of the preliminary reports.

8. *Lecidea sanguineoatra* (Wulf.) Ach. Meth. Lich. 50. 1803.

Lichen sanguineoater Wulf. in Jacq. Coll. Bot. 3: 116. 1789.

Thallus composed of commonly closely aggregated and even heaped, sea-green or ashy-gray, irregular or subhemispherical granules, these somewhat larger than those of the last, 0.1 to 3.5 mm. in diameter, and like the last widely spread over the substratum, but forming a somewhat thicker layer, never becoming smooth and chinky or subareolate; apothecia adnate, somewhat larger than in the last; 0.20 to 1 mm. in diameter, flattish to strongly convex, the margin disappearing in the latter condition, the disk dark rusty-brown passing through sanguineous to black with age, scarcely so much inclined to the strongly convex condition as in the last, the apothecia also not as much inclined toward the clustered condition; hypothecium brown; hymenium pale brownish; paraphyses simple or branched toward the apex, there commonly thickened and brownish; asci clavate or cylindrico-clavate; spores ellipsoid, varying toward fusiform, the 2-celled condition of the last not seen, 9 to 18 μ long and 3.5 to 5.5 μ wide.

Sometimes considered a subspecies of the last, but ours at least seems distinct.

Distribution and habitats in Minnesota the same as of the last.

To be looked for in all portions of the United States and northward at least to Newfoundland and Alaska, thus on the whole somewhat more southern in its distribution than the last. Known also in Europe, Asia, and Africa.

Biatora sanguineoatra of the preliminary reports.

9. *Lecidea carnulenta* (Tuck.) Fink.

Biatora carnulenta Tuck. Proc. Amer. Acad. 12: 179. 1877.

Thallus rudimentary or entirely disappearing; when present consisting of a very thin and usually scattered crust, this commonly sea-green to brownish in color and so inconspicuous as to appear only under a lens; apothecia small or minute, 0.2 to 0.6 mm. in diameter, flattish to convex, the disk pale flesh-colored and darkening, the exciple darker or disappearing, the disk sometimes faintly pruinose; hypothecium pale to pale-brownish; hymenium of the same color or darker above; paraphyses slender, simple or branched, sometimes enlarged and brownish toward the apex; asci clavate; spores ovoid-ellipsoid, 7 to 12 μ long and 3 to 5.5 μ wide.

Ours on the whole seems somewhat better developed than Tuckerman's plant and appears to have the apothecia rather darker externally and internally.

A single collection was made at Warroad. On dead wood. The plant has been collected in northern Iowa and no doubt exists in other portions of Minnesota, but it is scarcely noticeable except under a lens and is usually overlooked.

A North American lichen, previously known from New England, New York, Illinois, and Iowa.

Biatora carnulenta of the preliminary reports.

10. *Lecidea turgidula* Fr. Sched. Crit. Lich. Exsicc. Suec. 1: 10. 1827.

Thallus composed of minute, commonly more or less scattered, whitish to sea-green, irregular and commonly inconspicuous granules, these running together into a sub-continuous or subareolate and very thin crust or sometimes entirely disappearing; apothecia small to minute, 0.2 to 0.8 mm. in diameter, flattish to strongly convex, the exciple commonly absent, the disk from pale brownish to black, sometimes more or less white-pruinose; hypothecium brown; hymenium pale brownish; paraphyses simple or branched, slightly enlarged and brownish toward the apex; asci clavate; spores oblong to ellipsoid, 6 to 12 μ long and 3 to 5.5 μ wide.

Distributed throughout the northern portion of the State, apparently more common westward. On dead wood. Our Minnesota forms of the last two above seem very closely related, but both exist in the State, sometimes confusingly similar. Throughout northern United States and northward to arctic America. Known also in Europe and Asia.

Biatora turgidula of the preliminary reports.

11. *Lecidea panaeola* Ach. Lich. Univ. 201. 1810.

Thallus composed of minute, somewhat raised and irregular, scattered or contiguous, ashy-gray granules, these frequently running together into a verrucose or areolate crust of moderate thickness and often widely spread over the substratum, the areoles or verrucae 0.15 to 0.3 mm. in diameter; apothecia rather small, 0.3 to 1 mm. in diameter, adnate or somewhat immersed, dark brown to black, almost constantly the latter in ours, the exciple of the same color in ours, the disk flat or rarely somewhat convex; hypothecium pale or pale brownish; hymenium pale below and darkened above; paraphyses simple or rarely branched, frequently somewhat colored and thickened toward the apex; asci clavate; spores oblong-ellipsoid, 11 to 16 μ long and 6 to 8.5 μ wide.

Biatora leucophaea is the synonym under which the plant was recorded in the preliminary survey, where also a subspecies was recorded from Grand Portage, which evidently belongs elsewhere, though indeterminable from the material at hand. The spores are rather large in our plant and the apothecia internally and externally inclined to darker conditions.

Distributed throughout the northern portion of the State. On rocks.

Previously reported from arctic America. Known also in Europe and New Zealand.

12. *Lecidea uliginosa* (Schrad.) Ach. Meth. Lich. 43. 1803.

Lichen uliginosus Schrad. Spic. Fl. Germ. 88. 1794.

Thallus composed of scattered, clustered or even more or less heaped, irregular and very minute, greenish-olivaceous to rusty brown or even blackish, somewhat raised granules, these forming a widely scattered, frequently subleprose, subcontinuous or scattered crust; apothecia small or minute, 0.2 to 0.35 mm. in diameter, closely appressed or rarely more or less immersed, often clustered, brown or brownish black, the disk flat or rarely somewhat convex, the exciple thin, raised and lighter-colored, but becoming black and disappearing; hypothecium light or darker brown; hymenium yellowish or brownish; paraphyses simple or branched, slender, usually enlarged and brownish toward the apex; asci long-clavate; spores ovoid-ellipsoid, 8 to 15 μ long and 4.5 to 8 μ wide.

Distributed throughout the northern portion of the State and also collected as far south as Mankato and New Ulm. On earth and old wood.

Widely distributed in North America. Known also in Europe and Asia.

Biatora uliginosa of the preliminary reports.

12a. *Lecidea uliginosa fuliginosa* (Ach.) Leight. Lich. Fl. Great Brit. ed. 3. 274. 1879.

Lecidea fuliginosa Ach. Syn. Lich. 35. 1814.

Thallus on the whole rather less developed and the apothecia smaller; spores 6 to 9 μ long and 3.5 to 5 μ wide. The species is quite variable, and some half dozen subspecies are recognized in Europe.^a

Collected once in the State, at Beaudette. On an old Polyporus. Listed in the seventh preliminary report as a distinct species.

Not found reported from other portions of the Western Hemisphere, though no doubt to be looked for with the species. Well known in Europe and found also in Asia.

13. *Lecidea myriocarpoides* Nyl. Flora 48: 355. 1865.

Thallus composed of minute, irregular, and somewhat flattened or more rarely hemispherical, olivaceous-brown granules, 1.5 to 3 mm. in diameter, forming a continuous, usually rather thin, subleprose or rarely even subareolate, widespread crust, this liable to become scattered or obsolete; apothecia small or minute, 0.15 to 0.4 mm. in diameter, adnate, dark brown to black, flat or becoming convex and turgid, and the thin black exciple disappearing; hypothecium brown or blackish brown; hymenium pale, brownish or bluish; paraphyses somewhat gelatinized, simple or rather rarely branched, sometimes enlarged and darker toward the apex; asci clavate; spores ellipsoid, 6 to 9 μ long and 2.5 to 4 μ wide.

Generally distributed over the State. On dead wood, especially fences, and also on rocks. Dr. T. Hedlund has referred our rock specimens to *Lecidea sylvicola* Flot.^b but ours are all alike so far as we can determine. Possibly the older name should be adopted, but we await further studies.

From Minnesota and Iowa eastward throughout the eastern United States. Known also in Europe.

Biatora myriocarpoides of the preliminary reports.

^a Cf. Hedlund, Bih. Svensk. Vet. Akad. Handl. II 18^m: 72. 1892.

^b Lich. Sil. Exsicc. no. 171. 1829. Cf. Koerb. Syst. Lich. 254. 1855.

14. *Lecidea varians* Ach. Syn. Meth. Lich. 38. 1814.

FIGURE 10.

Thallus composed of very minute, irregular, raised or more or less flattened, pale yellowish or greenish granules, these running together to form a continuous, commonly thin, smooth or more or less granulate-rugose and often chinky crust, this more commonly somewhat orbicular and 7 to 20 mm. in diameter, usually bordered and sometimes decussate by black lines (the so-called hypothallus); apothecia adnate, very minute, 0.12 to 0.25 mm. in diameter, commonly flat, with a thin exciple, which soon disappears, the apothecia then becoming convex, often clustered and conglomerate, from pale yellowish varying to brown and finally black, said to be rarely white-pruinose; hypothecium pale or yellowish; hymenium pale below and frequently brownish or pale blue-violet above; paraphyses simple, the apex commonly enlarged and partaking of the color of the upper hymenium; asci clavate; spores ovoid-ellipsoid, 7 to 15 μ long and 5 to 7.5 μ wide.

Generally distributed over the State, but easily overlooked. On trees and old wood. A very variable plant.

Generally diffused over North America. Known also in Europe and Africa.

Biatora varians of the preliminary reports.

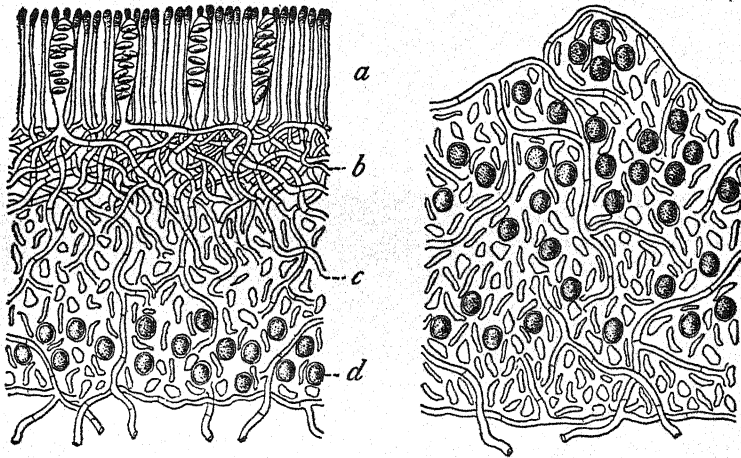


FIG. 10.—*Lecidea varians*, showing at the right a section of the rudimentary thallus and at the left a section of a portion of an apothecium. *a*, The hymenium; *b*, *c*, the hypothecium; *d*, the algal layer below the apothecium. Enlarged 300 diameters. From Schneider.

15. *Lecidea quercea* (Dicks.) Ach. Meth. Lich. 62. 1803.

Lichen querceus Dicks. Pl. Crypt. Brit. 1: 9. pl. 2. f. 3. 1785.

Thallus composed of small, usually more or less scattered, greenish, yellowish, or brownish granules, sometimes running together to form a thin, chinky crust, more or less widely spread over the substratum; apothecia adnate or immersed, small or minute, 0.3 to 1 mm. in diameter, commonly convex and becoming irregular in form, brown to black in color or slightly whitish-pruinose in some of ours, the exciple evanescent; hypothecium pale or brownish; hymenium pale; paraphyses more or less gelatinized and coherent-indistinct; asci clavate or cylindrico-clavate; spores ovoid-ellipsoid, 6 to 11 μ long and 4 to 7 μ wide.

Collected along the northern boundary at Warroad and at Rainy Lake City. On dead wood.

Elsewhere in North America in California. Known also in Europe.

Biatora quercea of the preliminary reports.

16. *Lecidea flavidolivens* (Tuck.) Fink.

Biatora flavidolivens Tuck. Syn. N. A. Lich. 2: 28. 1888.

Thallus composed of minute, irregular, and usually crowded and heaped, greenish to yellowish brown granules, these forming a commonly widespread continuous or somewhat scattered crust; apothecia minute, olivaceous to black in ours, 0.2 to 0.3 mm. in diameter, adnate or immersed, flat, with a pale exciple, or becoming convex and the exciple disappearing; hypothecium brownish or brown; hymenium pale or pale bluish; paraphyses simple, but more or less gelatinized and coherent; asci broadly clavate; spores simple or rarely 2-celled, 7 to 14 μ long and 3 to 4 μ wide.

Collected at Warroad. On a cedar stump in a swamp. The plant so reported from Rat Lake seems nearer the next. Tuckerman's plant had not the black apothecia and its spores are somewhat larger.

A North American lichen, elsewhere only known at New Bedford, Massachusetts.

Biatora flavidolivens of the preliminary reports.

17. *Lecidea lucida* Ach. Meth. Lich. 74. 1803.

Lichen lucidus Ach. Lich. Suec. 39. 1798.

Thallus composed of minute granules commonly breaking up into a fine, powdery crust, this usually widely spread over the substratum as a greenish yellow, continuous or more or less scattered, rather thin layer, or rarely more or less collected into little heaps; apothecia adnate, small to minute, 0.15 to 0.35 mm. in diameter, more or less convex, pale or darker lemon-color, passing into brownish, sometimes clustered or conglomerate, the exciple evanescent; hypothecium and hymenium pale yellowish; paraphyses commonly simple, but somewhat gelatinized, coherent and indistinct; asci clavate; spores oblong-ovoid, 4 to 7 μ long and 2 to 3 μ wide.

Widely distributed in northern Minnesota. On shaded rocks.

Elsewhere in North America known from New York, Massachusetts, and arctic America. Found also in Europe.

Biatora lucida of the preliminary reports.

18. *Lecidea oxyspora* (Tul.) Nyl. Act. Soc. Linn. Bord. 21: 391. 1856.

Abrothallus oxysporus Tul. Ann. Sci. Nat. Bot. III. 17: 116. pl. 16. f. 27. 1852.

Thallus evanescent or not distinguishable from that of the host, the latter deformed by the parasite and passing into small tufts of irregular or cucullate lobules; apothecia minute, 0.15 to 0.3 mm. in diameter, flattish or slightly convex, more or less immersed in the deformed thallus of the host, pale brown to black, without exciple; hypothecium pale brownish to brown; hymenium pale throughout or brownish above; paraphyses usually simple, commonly enlarged and brownish toward the apex; asci clavate; spores ellipsoid to fusiform, 15 to 20 μ long and 5 to 7.5 μ wide.

Generally distributed throughout the northern portion of the State. On Parmelias and especially common on *P. borrieri* on cedars in swamps.

Known elsewhere in North America from New England, Canada, and Ontario. Found in all of the grand divisions except Africa.

Biatora oxyspora of the preliminary reports.

19. *Lecidea laticida* Fr. Lich. Eur. 306. 1831.

Thallus more or less roughened, verrucose to areolate, sea-green or becoming more or less ash-colored, the areoles or verrucae about 0.5 to 1.75 mm. across, irregularly and often quite widely spread over the substratum as a rather thin crust; apothecia small, 0.3 to 1 mm. in diameter (said to become middle-sized), adnate or more or less immersed, sometimes clustered, the disk black and commonly flat, but frequently becoming convex and irregular, the exciple black and raised or finally disappearing; hypothecium usually dark brown; hymenium pale or more or less bluish below and darker above; paraphyses simple or rarely branched toward the commonly enlarged and darker apex; asci clavate; spores short-ellipsoid, 8 to 12 μ long and 4 to 7 μ wide.

Collected in the northern part of the State at Emo, at Rainy Lake City, and in the Misquah Hills. On rocks.

Elsewhere in North America in California and several localities in British America, extending northward to arctic America. Known also in Europe and New Zealand.

19a. *Lecidea lapicida oxydata* Tuck. Syn. N. A. Lich. 2: 70. 1888.

Thallus becoming rust-red.

The plant was collected at Grand Portage. On rocks.

Elsewhere in North America in California. Known also in Europe.

20. *Lecidea cyanea* (Ach.) Th. Fr. Lich. Scand. 2: 489. 1874.

Lecidea lapicida cyanea Ach. Meth. Lich. 38. 1803.

Thallus more or less roughened, chinky-areolate, sea-green, varying toward ashy, occurring in rounded areas or more widely and irregularly spread over the substratum, the verrucae about 0.5 to 1.25 mm. across; apothecia often reaching middle size, in ours only 0.3 to 0.6 mm. in diameter, adnate and more commonly immersed, the disk black and flat, the exciple black and persistent; hypothecium pale or finally pale brownish; hymenium pale; paraphyses simple or rarely branched, commonly enlarged and darker toward the apex; asci clavate; spores ellipsoid, 8 to 12 μ long and 4 to 7 μ wide.

Collected at Pipestone; not previously reported from Minnesota. On pipestone.

Elsewhere in North America from New England, Florida, Nebraska, South Dakota, Oregon, California, and throughout British America. Known also in Europe and South America.

Lecidea tessellata of Tuckerman's Synopsis.

21. *Lecidea lithophila* Ach. Syn. Meth. Lich. 14. 1814.

Lecidea lapicida lithophila Ach. Lich. Univ. 160. 1810.

Thallus at first smoothish, but becoming more or less chinky, ashy or sea-green, sometimes disappearing, ours suborbicular or more or less irregularly spread over the substratum, the more regular thalli 30 to 50 mm. in diameter; apothecia small to minute in ours, 0.25 to 0.9 mm. in diameter, sometimes clustered and more or less angular, the disk black or blackish brown, commonly flat or only slightly convex, rarely somewhat pruinose, the exciple lighter-colored and seldom disappearing; hypothecium pale and finally pale brownish; hymenium pale throughout or darker above; paraphyses simple or rarely branched, somewhat coherent, frequently enlarged and darker toward the apex; asci clavate; spores oblong-ellipsoid, 11 to 15 μ long and 6 to 7 μ wide.

Collected on rocks at Grand Portage. Not previously reported from Minnesota.

Not known elsewhere in North America. Well known in Europe, and found also in Asia.

22. *Lecidea contigua* Fr. Sched. Crit. Lich. Exsicc. Suec. 13: 14. 1827.

Thallus more or less roughened, becoming somewhat chinky and finally subareolate, sea-green, and finally more or less ashy, irregularly spread over the substratum, sometimes thin and somewhat scattered; apothecia small to middle-sized, 0.5 to 1.5 mm. in diameter, from more or less immersed becoming adnate and subsessile, the disk black and flat or finally convex, the exciple rather thin, black, and persistent; hypothecium dark brown; hymenium pale or brownish; paraphyses simple or not rarely branched, commonly thickened and brownish toward the apex; asci clavate or narrowly clavate; spores ovoid-ellipsoid, 10 to 16 μ long and 5 to 7 μ wide.

Collected on Grand Portage Island. On rocks.

Found in New England, New York, Pennsylvania, and Florida, and in various portions of British America. Known in all of the grand divisions.

Lecidea crustulata of the preliminary reports. The two names sometimes occur in the same list of lichen species, and they may yet prove to represent two distinct species.

22a. *Lecidea contigua convexella* (Wainio) Fink.

Lecidea crustulata convexella Wainio, Act. Soc. Faun. Flor. Fenn. 10: 74. 1883.

Form with apothecia commonly becoming convex and the exciple disappearing.

Collected at Grand Marais and not previously reported from Minnesota. On rocks.

Not known elsewhere in North America. Found also in Europe.

23. *Lecidea lactea* (Flot.) Schaer. Lich. Helv. Spic. 3: 127. 1828.

Lecidea petraca lactea Flot. Flora 2: 692. 1828.

Thallus ashy, varying toward whitish or sea-green, of moderate thickness, at first smooth, but becoming more or less roughened and chinky or areolate, suborbicular or somewhat irregular, commonly 35 to 75 mm. across, forming a continuous layer and sometimes becoming thicker in ours; apothecia small to middle-sized or larger, 0.4 to 2.5 mm. in diameter, immersed or rarely becoming adnate, the disk black and commonly flat, the exciple thin and frequently disappearing; hypothecium brown or brownish; hymenium pale or pale brownish below and somewhat darker above; paraphyses commonly simple, frequently more or less coherent, sometimes enlarged and darker above; asci clavate or cylindrico-clavate; spores ellipsoid, 9 to 14 μ long and 4 to 6 μ wide.

Collected at several localities on the north shore of Lake Superior. On rocks.

Apparently not reported elsewhere in North America. Known in all of the grand divisions.

24. *Lecidea speirea* Ach. Meth. Lich. 52. 1803.

PLATE 6, A.

Lichen speireus Ach. Lich. Suec. 59. 1798.

Thallus white, or whitish-ashy and sometimes mealy, smoothish and chinky or becoming areolate or subareolate, scarcely as thick as that of the last above, usually in smaller patches than in the last and commonly irregular, about 15 to 50 mm. across, sometimes becoming rougher; apothecia small in ours, but said to reach more than middle size, immersed or becoming adnate, the disk black and commonly flat, but sometimes finally convex, the exciple black or whitish-pruinose, frequently disappearing; hypothecium brown or dark brown; hymenium commonly pale below and darker above; paraphyses commonly simple, frequently more or less coherent, commonly enlarged and darker toward the apex; asci clavate; spores ellipsoid, 9 to 14 μ long and 5 to 8 μ wide.

Collected with the last along the north shore of Lake Superior, where the two occur on the rocks, usually from the water line back not more than 5 meters.

Known in New England and from the north shore of Lake Superior in Ontario. Found also in Europe and Africa.

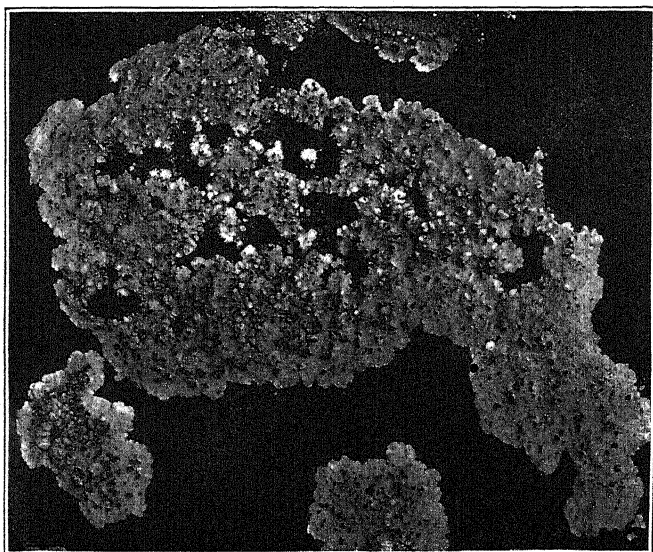
EXPLANATION OF PLATE 6.—A, Plants of *Lecidea speirea* on rocks, showing the thallus and the apothecia. B, Plants of *Lecidea albocaulerulescens* on rocks, showing the crustose thallus and the apothecia. A enlarged $1\frac{1}{2}$ diameters; B natural size.

25. *Lecidea albocaulerulescens* (Wulf.) Schaer. Lich. Helv. Spic. 3: 142. 1828.

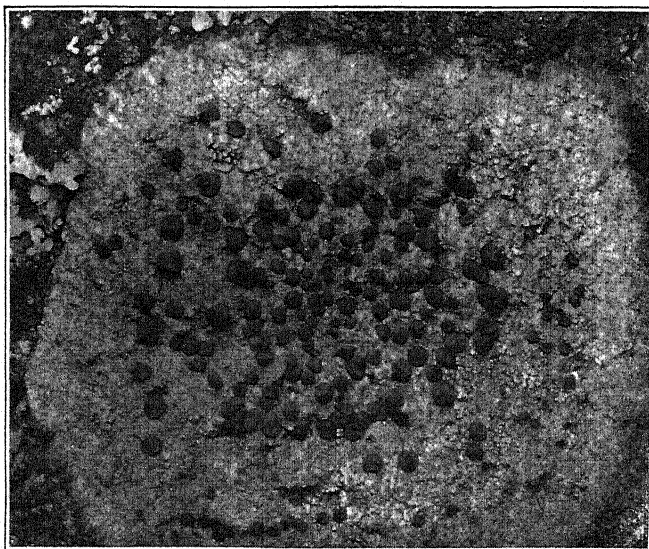
PLATE 6, B.

Lichen albocaulerulescens Wulf. in Jacq. Coll. Bot. 2: 184. pl. 15. f. 1. 1788.

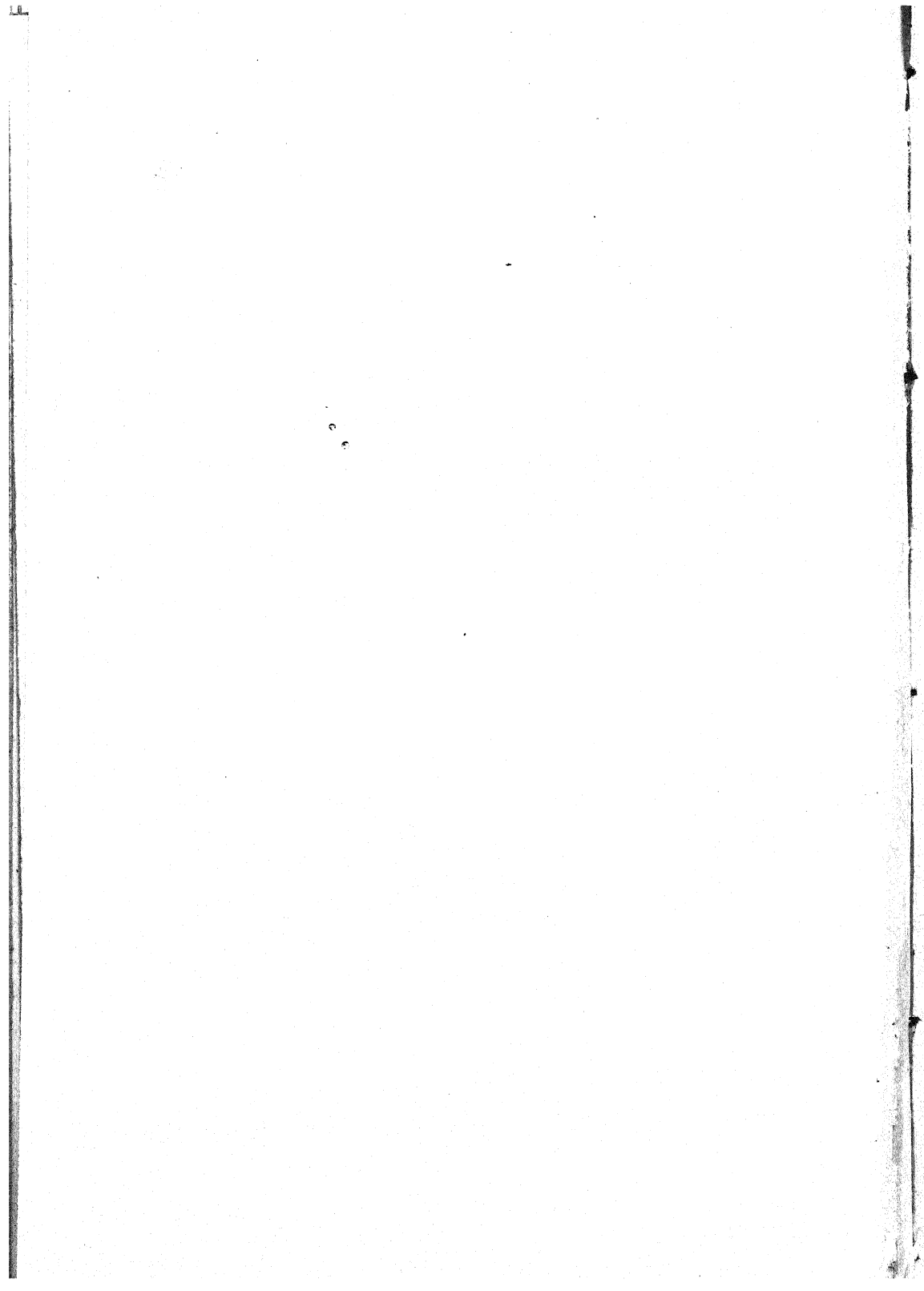
Thallus commonly thinner than those of the last two, rather smoothish, more or less chinky and sometimes becoming obscurely small-areolate, ashy or varying toward whitish, sea-green or even olivaceous, spread over the substratum as a continuous crust, suborbicular or irregular and often covering quite large areas; apothecia small to middle-sized, 0.5 to 1.5 mm. in diameter, or 2 mm. or more in foreign material, adnate or rarely somewhat immersed, rounded or becoming irregular, the disk black or brownish black, usually flat, almost always more or less whitish-pruinose, the exciple black, seldom if ever disappearing; hypothecium brown to brownish black; hymenium commonly pale; paraphyses simple or rarely branched, somewhat coherent, commonly enlarged and darker toward the apex; asci clavate or inflated-clavate; spores ovoid-ellipsoid, 15 to 24 μ long and 7 to 10 μ wide.



A. *LECIDEA SPEIREA* ACH.



B. *LECIDEA ALBOCAERULESCENS* (WULF.) SCHAER.



Collected at Taylors Falls and in the Misquah Hills. On rocks.

Found in the Appalachian Mountains from Alabama northward as far as Newfoundland and in Alaska. Known also in Europe and Asia.

26. *Lecidea cyrtidia* Tuck. Proc. Amer. Acad. 12: 181. 1877.

Thallus composed of very minute scattered or sometimes crowded, scurfy granules, sea-green or more commonly varying toward greenish or olivaceous, the whole structure very inconspicuous and irregularly, frequently widely, spread over the substratum; apothecia also minute and closely adnate (so that the plant is frequently difficult to detect), 0.2 to 0.5 mm. in diameter, the disk black, at first flat but soon becoming convex, the exciple thick and black, but soon disappearing; hypothecium rather thick, pale, or more commonly brown; hymenium pale below and brownish above; paraphyses simple or rarely branched, sometimes more or less coherent, commonly enlarged and brownish toward the apex; asci clavate; spores ovoid-ellipsoid, 5 to 9 μ long and 2 to 4 μ wide.

Collected near Snowbank Lake and at Rainy Lake City, thys on or near the northern boundary. On rocks.

A North American species known in New England, Illinois, and Missouri.

27. *Lecidea platycarpa* Ach. Lich. Univ. 173. pl. 2. f. 5. 1810.

Thallus thin, more or less chinky and finally subareolate, sometimes becoming wrinkled, sea-green to ashy, or tinged red by iron, irregularly spread over the substratum as a continuous or more commonly as a more or less broken crust, and frequently for most part or entirely disappearing; apothecia small to middle-sized or even larger, 0.5 to 1.5 mm. in diameter, or larger in foreign specimens, usually scattered, sessile or adnate, the disk flat or becoming somewhat convex, black or brownish, rarely slightly pruinose, rounded or becoming somewhat irregular, the exciple thickish and becoming more or less flexuous and disappearing; hypothecium thick and blackish brown; hymenium pale below and pale brownish above; paraphyses simple or rarely branched, commonly somewhat enlarged and brownish toward the apex; asci clavate; spores ovoid-ellipsoid, 11 to 18 μ long and 5 to 9 μ wide.

Reported from the Misquah Hills and from Blueberry Island in Lake of the Woods, though the material from the former locality will doubtless have to be placed elsewhere eventually. On rocks.

Elsewhere in North America in New England, New York, Virginia, North Carolina, Ohio, and South Dakota. Known also in South America and Europe.

28. *Lecidea enteroleuca* Ach. Lich. Univ. 177. 1810.

Thallus commonly rather thin, smoothish, or more often variously chinky, areolate; the granules or verrucae rarely becoming heaped and the thallus then thicker, this sea-green varying toward ashy, suborbicular, or variously irregular and more widely spread over the substratum, the more rounded thalli commonly 15 to 65 mm. across; apothecia minute to scarcely middle-sized, 0.3 to 1 mm. in diameter in ours, adnate, the disk black and soon becoming more or less convex, the exciple soon flexuous and disappearing; hypothecium pale to dark brown; hymenium pale below and more or less darkened above; paraphyses simple or sometimes branched, frequently more or less coherent, usually enlarged and brownish toward the apex; asci clavate, the apical wall more or less thickened; spores ovoid-ellipsoid, 8 to 17 μ long and 5 to 9 μ wide.

Generally distributed over the State, and often appearing as one of the subspecies below. On trees, old wood, and various rocks.

Distributed throughout North America. Known also in all of the grand divisions.

28a. *Lecidea enteroleuca theioplaca* Tuck. Gen. Lich. 179. 1872.

Thallus verrucose, pale yellowish; hypothecium dark and blackening; thallus with a greenish yellow cast in ours.

Collected at Harding on the northern boundary of the State. On rocks.

A north American subspecies, known also from New Jersey, South Carolina, Iowa, and California.

28b. *Lecidea enteroleuca achrista* (Sommerf.) Tuck. Syn. N. A. Lich. 2: 80. 1888.

Lecidea elaeochroma achrista Sommerf. Suppl. Fl. Lapp. 150. 1826.

Thallus at first thin and smoothish, but becoming chinky or verrucose, whitish or rarely becoming dark-ashy; apothecia more inclined to remain flat and often becoming flexuous; hypothecium brownish yellow.

Collected at Grand Portage, Granite Falls, Battle Lake, and Red Lake. On trees. Throughout the United States and northward into British America. Known also in Europe.

28c. *Lecidea enteroleuca flavida* Fr. Vet. Akad. Handl. 1822: 261. 1822.

Thallus thin and smoothish, limited and variegated by black lines; apothecia sometimes with a thin gray bloom; hypothecium yellow to brownish black.

Collected at several points in the northwestern portion of the State. On trees.

Found elsewhere in North America in New England and Alaska. Known also in Europe.

28d. *Lecidea enteroleuca pilularis* (Dav.) Th. Fr. Lich. Scand. 2: 543. 1874.

Lichen pilularis Dav. Trans. Linn. Soc. Lond. 2: 283. 1794.

Thallus verrucose or areolate-verrucose, sea-green varying toward ashy, or even whitish, the verrucæ frequently scattered or disappearing; hypothecium pale (or sometimes brownish in ours).

Collected at Koochiching, at Tower, and on Flag Island in Lake of the Woods.

Elsewhere in North America on the Rideau River and at Aylmer in Canada. Well known in Europe.

Lecidea goniophila of the preliminary reports. In determining this again from the St. Peter sandstone at Minneapolis, the eminent authority, Dr. T. Hedlund, insists that *L. goniophila* (Floerke) Koerb. is distinct from *L. enteroleuca* Ach. We let the above disposition stand with this note, though Doctor Hedlund's disposition is to be respected.

28e. *Lecidea entroleuca ambigua* (Mass.) Tuck. Syn. N. A. Lich. 2: 80. 1888.

Biatora ambigua Mass. Ric. Lich. 124. f. 242. 1852.

Thallus thin and smoothish; apothecia brownish flesh-colored to blackish and thinly pruinose; hypothecium as above.

Collected at several points in the northwestern portion of the State. On old wood.

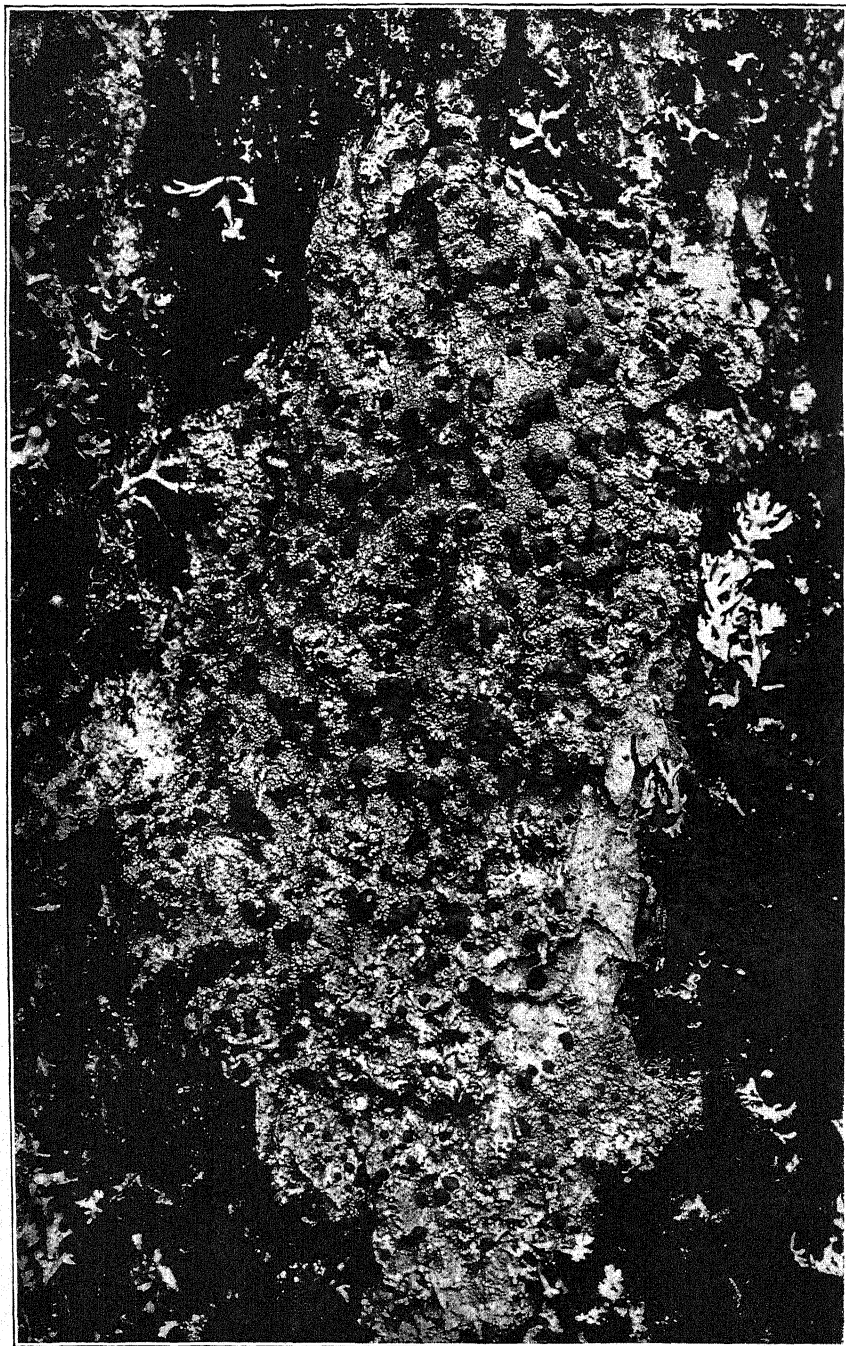
Elsewhere in North America in Washington and Oregon. Known also in Europe.

29. *Lecidea melancheima* Tuck. Syn. Lich. N. E. 68. 1848.

PLATE 4.

Thallus thicker, rough, wrinkled and verrucose, sea-green or ashy, usually irregularly spread over larger or smaller areas of the substratum, at first as a continuous crust, but the verrucæ becoming more or less scattered and finally tending to disappear, possibly rarely subareolate; apothecia small to scarcely middle-sized, 0.5 to 1 mm. in diameter, adnate, frequently clustered and irregular, the disk very black, at first flat but becoming convex, the exciple soon disappearing and leaving the frequently shining disk without margin; hypothecium pale (or in ours becoming brownish or brown); hymenium pale below and usually brownish above; paraphyses simple or sometimes branched, frequently more or less coherent, usually enlarged and darker toward the apex; asci clavate; spores oblong-ellipsoid, 7 to 12 μ long and 3 to 4.5 μ wide.

Lecidea elabens Fr. from Warroad, determined by Dr. T. Hedlund, scarcely differs.



MEGALOSPORA SANGUINARIA (L.) KOERB.

Collected at Gunflint, along Snowbank Lake and in the Misquah Hills. On old wood.

Found in New England, Iowa, Colorado, and Alaska. Known also in Europe.

EXPLANATION OF PLATE 4.—See page 67.

MEGALOSPORA Meyer, Nov. Act. Acad. Caes. Leop. Car. Suppl. 19¹: 228. 1843.

The thallus is crustose and variously roughened and verrucose. There is no distinct cortical layer, nor were the algal and medullary layers very distinctly differentiated in most of the material examined. The algae are modified forms of *Cystococcus*, the cells varying considerably in size and form. Hyphal rhizoids serve for attaching organs, but are neither numerous nor conspicuous in the sections. The thallus is further described under our single species of the genus.

The apothecia are middle-sized or large, and are adnate. The exciple is proper and is evanescent, the disk commonly more or less convex. The hymenium and the hypothecium are sufficiently characterized in the description of the species. The spores are simple, hyaline, very large, one in each ascus.

Tuckerman included our single species in the genus *Heterothecium*, which includes also species having compound spores and others having compound-muriform and brown spores. That such a genus should not stand is certain enough. The present genus is closely related to *Lecidea*, from which it differs in the large and solitary spores and also in the commonly present red coloration of the hypothecium or adjoining portions of the apothecium. Perhaps the 2-celled members of the genus *Heterothecium* of Tuckerman's Synopsis are as closely related to the present genus as are the *Lecideas*.

The single American species and a subspecies occur in the northern portion of the State. On trees and dead wood.

Type species *Megalospora sulphurata* Meyer, loc. cit.

1. *Megalospora sanguinaria* (L.) Koerb. Syst. Lich. 257. 1855.

PLATE 7.

Lichen sanguinarius L. Sp. Pl. 1140. 1753.

Thallus crustose, consisting of granules, these commonly becoming flattened and running together into a verrucose and more or less chinky and polished crust, sea-green, varying toward ashy, commonly widely and irregularly spread over the substratum as a continuous crust of moderate thickness; apothecia middle-sized or larger, 1 to 3 mm. in diameter, adnate, sometimes clustered and becoming irregular, the disk black and more or less shining, commonly convex, the exciple pale or rarely darkening or reddish, soon disappearing and seldom seen except in very young apothecia; hypothecium pale above and reddish below and resting upon a blood-red layer (hypothecium said to be sometimes black, while some authors consider the whole structure pale and the red layer wholly subhypothecial and others yet speak of the hypothecium as red); hymenium pale or reddish brown below and only slightly darker above; paraphyses simple or rarely branched, somewhat thickened and darker toward the apex; asci clavate or more or less irregular; spores oblong-ellipsoid, hyaline or pale, 56 to 90 μ long and 22 to 46 μ wide.

Thus far collected only in the northeastern portion of the State. On trees and old wood and rarely on rocks.

Elsewhere in North America, in New England, New York, California, and Oregon, and widely distributed in British America. Known also in Europe and Asia.

Heterothecium sanguinarium of the preliminary reports.

EXPLANATION OF PLATE 7.—Plants on wood, showing the crustose thallus and the apothecia. Enlarged to about 1½ diameters.

1a. *Megalospora sanguinaria affinis* (Schaer.) Fink.

Lecidea affinis Schaer. Enum. Lich. Eur. 132. 1850.

Apothecia without the red coloration below the hymenium and in the exciple; whole plant smaller in ours.

Collected at Rose Lake along the northern boundary. On old wood.

Referred to by Tuckerman, but without giving localities. Known also in Europe and Asia.

Heterothecium sanguinarium affine of the preliminary reports.

BIATORINA Mass. Ric. Lich. 134. f. 262-271. 1852.

The thallus is crustose and commonly granulose and often passes into verrucose or rugose-verrucose conditions, but is seldom or never in any degree areolate. It is thinner as a whole than that of Lecideas and is more commonly rudimentary or evanescent. The thallus development is on the whole better than in Biatorella, but there is no suggestion of a cellular cortex in any of the species examined. Neither are there any internal tissue layers. As in the closely related genera, the rudimentary structure lies mainly above the substratum and is attached by hyphal rhizoids. The algal cells, in ours at least, are the common Cystococcus, though others insist that *Chroolepus* is the common form.

The apothecia are usually small or minute and are commonly adnate. The exciple is as in section *Biatora* of the Lecideas, and frequently disappears, leaving the apothecium without margin. The disk is flat or more or less convex. The hypothecium and the hymenium vary in color from pale to brownish or brown, though bluish or pale violet shades are to be looked for in the upper portion of some hymenia. The spores are 2-celled, hyaline, and variously ovoid, oblong, ellipsoid, or even somewhat fusiform.

The genus is doubtless derived phylogenetically from some form or forms of Lecidea, and this view is strengthened by the fact that among the Lecideas, and probably among Biatorinas also, there are species having both simple and 2-celled spores. On the other hand, the relationship between the present genus and *Bilimbia* is perhaps as close, and it appears reasonable to suppose that the *Bilimbias* were derived from certain Biatorinas, by a second cell division of the spores, or the latter perhaps more probably from the former by spore degeneration, the same being true for Lecideas and Biatorinas. The exciple is a rather weaker structure even than that of the section *Biatora*, and this condition and the presence of a septum in the spores removes the members of the present genus further from our common Eulecideas than from members of the above section. In some respects the species of the genus *Gyalecta* as viewed by Tuckerman seem quite closely related to the present genus, or to *Bilimbia* or *Bacidia*. It may well be questioned, in view of the transitional forms, whether Lecideas and Biatorinas should be separated.

Thus far only five representatives of Biatorina have been met with in Minnesota. Four occur on wood and the fifth is parasitic on another lichen.

Type species *Biatorina griffithii* (Ach.) Mass. loc. cit.

KEY TO THE SPECIES.

- Parasitic on *Peltigera*, with very inconspicuous thallus and apothecia..... 3. *B. heerii*.
- Not parasitic on other lichens.
- Thallus remaining ashy.
- Spores normal; thallus inconspicuous and apothecia small or minute..... 1. *B. tricolor*.
- Spores sometimes simple; plants otherwise as above... 1a. *B. tricolor atlantica*.
- Thallus not often finally ashy.
- Thallus usually becoming greenish or brownish; apothecia small or minute, brown or blackish..... 2. *B. atropurpurea*.
- Thallus olivaceous-greenish or blackish; apothecia small or minute, brown or becoming blackish..... 4. *B. prasina*.

1. *Biatorina tricolor* (With.) Fink.

Lichen tricolor With. Arr. Brit. Pl. ed. 3: 20. 1796.

Thallus composed of very minute granules, these commonly running together to form a thin, more or less chinky or obscurely rugose-verrucose, ashy crust, continuously widespread over the substratum or more or less scattered; apothecia small or minute, in ours 0.15 to 0.25 mm. in diameter, adnate, the disk flat or slightly convex, flesh-colored passing through shades of brown to blackish, the paler exciple sometimes disappearing (disk said by Tuckerman to be pruinose); hypothecium pale or yellowish; hymenium pale throughout, or sometimes brownish above; paraphyses commonly simple, the apex frequently somewhat thickened and brownish; asci clavate or cylindrico-clavate; spores oblong, varying toward ellipsoid or fusiform, and sometimes more or less curved, 9 to 15 μ long and 3 to 4.5 μ wide.

Generally distributed over the northern portion of the State. On trees, especially on poplars. Both this and the next two are easily confused with *Arthonia patellulata*, which most commonly grows on the same substratum.

Widely distributed in the northern United States and northward to arctic America, also found in Florida and southern California. Known also in Europe and Africa.

Biatora mixta is the synonym used in the preliminary reports.

1a. *Biatorina tricolor atlantica* (Tuck.) Fink.

Biatora mixta atlantica Tuck. Syn. N. A. Lich. 2: 30. 1888.

Thallus as in the above, as is also the whole external appearance; internally differing in that the spores are frequently, and in some specimens commonly, simple. The plant is little known, and it may possibly represent immature conditions. If not, it is an interesting connecting form between the present genus and *Lecidea*.

Collected at Battle Lake. On poplars.

Elsewhere noted only in New England.

Biatora mixta atlantica is the synonym used in the preliminary reports.

2. *Biatorina atropurpurea* (Schær.) Mass. Ric. Lich. 135. f. 265. 1852.

Lecidea sphaeroides atropurpurea Schær. Enum. Lich. Eur. 140. 1850.

Thallus composed of very minute granules, these usually running together to form a somewhat chinky or leprose, widespread, thin, and rarely more or less sorediate crust, ashy in color, varying toward greenish or brownish and sometimes disappearing; apothecia small or minute, 0.18 to 0.35 mm. in diameter, adnate or slightly immersed in the thin thallus, the disk flat to strongly convex, the exciple disappearing early in ours, and the oftentimes immersed apothecia having thus a falsely lecanoroid appearance, brown and varying toward blackish; hypothecium pale or pale brownish; hymenium pale or pale brownish below and darker above; paraphyses commonly simple, usually somewhat thickened and brownish toward the apex, asci cylindrico-clavate; spores ellipsoid, 10 to 16 μ long and 3.5 to 6 μ wide.

Spores somewhat narrower, exciple more evanescent, and apothecia smaller than in the plant as described by Tuckerman and Th. Fries, and our plant on the whole perhaps intermediate between theirs and the last above.

Throughout the northern portion of the State. On trees, especially on poplars.

Reported also from New England, Illinois, Florida, California, and points northward through eastern British America to Newfoundland. Well known also in Europe, but further distribution scarcely to be ascertained in the present state of synonymy.

Biatora atropurpurea of the preliminary reports.

3. *Biatorina heerii* (Hepp) Fink.

Biatora heerii Hepp, Spor. Flecht. Eur. pl. 16. f. 135. 1853.

Thallus composed of very minute rounded and frequently heaped granules, sometimes visible with a lens, often seen only in sections, rarely disappearing entirely; apothecia minute, 0.1 to 0.2 mm. in diameter, sessile or adnate, flesh-colored and black-

ening, the disk flat or slightly convex, the exciple of about the same color or becoming darker, usually persistent; hypothecium colorless to brownish; hymenium of same colors and frequently darker below; paraphyses commonly simple, sometimes slightly thickened and brownish toward the apex; asci clavate; spores ovoid to ellipsoid, 7 to 12 μ long and 3 to 5.5 μ wide.

A single collection was made at Tower. On *Peltigera canina*.

Known elsewhere in North America in Massachusetts, Illinois, and Newfoundland. Found also in Europe, Asia, and Africa.

Biatora heerii of the preliminary reports.

4. *Biatorina prasina* (Fr.) Fink.

Micarea prasina Fr. Syst. Orb. Veg. 257. 1825.

Thallus composed of very minute granules, these closely clustered or even sometimes heaped more or less and forming a widely spread, frequently subleprose, usually dark olivaceous-green or blackish crust; apothecia small or minute, 0.2 to 0.5 mm. in diameter, commonly convex or globular and the exciple disappearing early, brown or in ours more commonly black or blackish, the whole structure in ours frequently irregular or depressed; hypothecium pale or brownish; hymenium pale below and commonly darker above; paraphyses commonly simple, somewhat gelatinized and indistinct; asci clavate; spores commonly 2-celled, but in ours more commonly simple, oblong-ovoid, 8 to 12 μ long and 3.5 to 5 μ wide.

Dr. A. Zahlbruckner has placed ours under subspecies *byssacea* (Zwackh) Th. Fr., based on the darker color of the apothecia, the darker apices of the paraphyses, and the frequently simple spores.

A single collection was made at Bemidji. On old wood.

Reported elsewhere in North America from Massachusetts, Illinois, Georgia, Washington, and California. Known also in Europe.

Biatora prasina of the preliminary reports.

BILIMBIA De Not. Giorn. Bot. Ital. 2¹:190. 1846.

The thallus is crustose and commonly composed of minute granules, which run together into a smooth or variously leprose or verrucose crust, never distinctly areolate, in any of our species at least, though squamose in some North American species. Thallus on the whole somewhat less conspicuous and also more rudimentary internally than in Lecideae, though seldom disappearing entirely. In position relative to the substratum and mode of attachment to it similar to Lecideae. The algal symbiont is a modified form of Cystococcus, in which the cells are perhaps on the whole smaller than usual and united in larger numbers.

The apothecia, like those of *Biatorella* and *Biatorina*, are small or minute, none of our members of this or of those genera reaching the middle-sized conditions so frequent among Lecideae and Bacidias. In form of apothecia, nature and constancy of exciple, color of hypothecium and hymenium, and appearance of paraphyses and asci, the present genus is essentially like the four closely related genera just mentioned. However, the spores differ from those of *Biatorinas* in that they are from 4 to 9-celled, and from those of *Bacidias* in that they are distinctly wider and on the whole shorter and fusiform or finger-shaped instead of being needle-shaped.

The Bilimbias are evidently most closely related to the Bacidias, and indeed it may well be doubted whether the species should be separated into two genera. The species, however, form two groups, whether genera or not, and though the student will find some trouble at first in deciding with which a species having a given spore form should be placed, the difficulty will pass away with a little observation of the various forms. Transitional spore forms scarcely exist in our species, though some real difficulty due to such is encountered in the study of certain forms from other regions. The plant of the preliminary reports placed in the genus Lecideae, under the name *Lecidea acclinis* Flot., appears to present stronger affinities with the present genus and has been transferred.

Though only four *Bilimbias* have thus far been found in the State, some one or more of them may be looked for on almost any common kind of lichen-bearing substratum.

Type species *Bilimbia hexamera* De Not. loc. cit. (*Bilimbia hypnophila* (Ach.) Th. Fr.)

KEY TO THE SPECIES.

Spores 4-celled; apothecia small, usually adnate, strongly convex, flesh-colored to reddish brown..... 1. *B. sphaeroides*.

Spores 4 to 8-celled.

Apothecia always black, small or minute, usually flat..... 4. *B. acclinis*.

Apothecia becoming black.

Apothecia at first light brown; hypothecium pale brownish to brown..... 2. *B. hypnophila*.

Apothecia at first flesh-colored; hypothecium pale to pale brownish..... 3. *B. naegelii*.

1. *Bilimbia sphaeroides* (Dicks.) Koerb. Syst. Lich. 213. 1855.

Lichen sphaeroides Dicks. Pl. Crypt. Brit. 1: 9. pl. 2. f. 3. 1785.

Thallus composed of minute, closely aggregated or even heaped, greenish, sea-green, or ashy granules, these forming a usually continuous, thin, and widely spread crust, this sometimes becoming leprose or only subgranulose, rarely also becoming thicker, and the granules raised and subcoralloid, or the thin crust almost entirely disappearing; apothecia small, 0.25 to 0.95 mm. in diameter, adnate or rarely sessile, becoming strongly convex and even subglobose, scattered or clustered, flesh-colored to reddish brown, the thin exciple disappearing early; hypothecium pale to light brown; hymenium pale to pale brownish; paraphyses simple or branched toward the apex, this is commonly somewhat enlarged and brownish; asci long-clavate; spores ellipsoid to fusiform, 4-celled, 13 to 23 μ long and 4 to 7 μ wide.

Generally distributed over the northern portion of the State, but rather rare. On mossy tree bases and more rarely on old wood.

Reported from Florida, but otherwise confined in the United States to the White Mountains (New Hampshire) and the Rocky Mountains. Common throughout British America. Known also in Europe and Asia.

Biatora sphaeroides of the preliminary reports.

2. *Bilimbia hypnophila* (Ach.) Th. Fr. Nov. Act. Reg. Soc. Sci. Ups. III. 3: 283. 1861.

Lecidea hypnophila Ach. Lich. Univ. 199. 1810.

Thallus composed of minute, crowded, and sometimes more or less confluent granules, these forming a crust scarcely differing in appearance from that of the last, tending to disappear when on wood; apothecia smaller than in the last, 0.2 to 0.75 mm. in diameter, becoming strongly convex and the exciple disappearing, light brown to black, adnate or sessile, scattered or clustered; hypothecium pale brownish to dark brown; hymenium pale or pale brownish below and darker above; paraphyses simple or rather rarely branched, commonly enlarged and brownish toward the apex; asci clavate or long-clavate; spores ellipsoid to fusiform, 4 to 8-celled, 16 to 32 μ long and 4 to 7.5 μ wide.

Though very close to the last, the two, commonly united by European lichenists, seem distinct as exhibited in our region. Differences in spore measurements, as also in size and internal and external coloration of apothecia, are obvious, *Bilimbia sphaeroides* reminding one externally of *Biatora vernalis*.

Generally distributed over the State. On mossy tree bases, or more rarely on earth or old wood.

Generally distributed over North America, being quite as common northward as the last and also well represented southward. Present in Europe, but commonly included with the last above.

Biatora hypnophila of the preliminary reports.

3. *Bilimbia naegelii* (Hepp) Zwackh, Flora 45: 505. 1862.

Biatora naegelii Hepp, Spor. Flecht. Eur. pl. 4. f. 1, 19. 1853.

Thallus composed of granules somewhat coarser than in the last two and usually somewhat flattened to form a chinky or more or less irregularly roughened crust, this confined to suborbicular patches, 5 to 15 mm. or more in diameter, or widely scattered as a usually thin layer, commonly sea-green to ashy, but ours quite uniformly darker and even tending toward olivaceous; apothecia small, 0.2 to 0.9 mm. in diameter, scattered or more commonly numerous and more or less clustered, adnate or rarely sessile, flat and with thin exciple, or more commonly convex and immarginate, dark brown to black, said to be at first flesh-colored; hypothecium pale or pale brownish; hymenium pale throughout or brownish above; paraphyses simple or rarely branched, commonly thickened and darker toward the apex; asci clavate; spores fusiform-ellipsoid, commonly 4-celled, 18 to 25 μ long and 3.5 to 5.5 μ wide, said to be sometimes 6 or 8-celled.

Collected at Beaver Bay and at Granite Falls. The plant is usually difficult to detect, being easily passed over for some other species, and is doubtless quite generally distributed over the State.² On trees.

Known elsewhere in North America in Massachusetts and Florida. Common in Europe.

Biatora naegelii of the preliminary reports.

4. *Bilimbia acclinis* (Koerb.) Fink.

Arthrosporum accline Koerb. Syst. Lich. 270. 1855.

Thallus composed of minute granules, these commonly compacted into a rugose-verrucose or subleprose crust, in the few specimens seen covering small irregular or suborbicular patches of substratum, 6 to 14 mm. in diameter, sea-green to ashy, frequently disappearing; apothecia small or minute, 0.5 to 0.75 mm. in diameter, said to reach 1 millimeter, adnate, flat and having a thin exciple or becoming convex and immarginate, black, commonly scattered; hypothecium pale brownish; hymenium pale below and somewhat darkened above; paraphyses slender and frequently branched, commonly thickened and dark-colored above; asci clavate or inflated-clavate; spores becoming 4-celled, somewhat curved and usually plainly constricted at the septa, sometimes more than 8 in each ascus, 9 to 18 μ long and 4 to 5 μ wide.

Collected at Gunflint, Battle Lake, and Thief River Falls. On trees. Another inconspicuous lichen, which doubtless occurs in other portions of the State. The species has been collected in northern Iowa and may be looked for in southern Minnesota.

Elsewhere in North America in Massachusetts, New Hampshire, and Nebraska. Known also in Europe.

Lecidea acclinis is the synonym under which the plant occurs in the preliminary reports.

BACIDIA De Not. Giorn. Bot. Ital. 2: 189. 1846.

The thallus is crustose and granulose, showing chinky, verrucose, or even subareolate or subsquamulose conditions. The margins in some of the best developed North American species are more or less lobulate, and the whole macroscopic structure only slightly inferior to that of the Lecideas and better developed than in *Bilimbia*. The thallus is frequently somewhat obscure, but seldom or never entirely disappears. Microscopically it is quite as rudimentary as in the two genera named above, and the algal symbiont is also apparently *Cystococcus*. The position and attachment to the substratum is likewise quite the same as in the closely related genera of the group.

The apothecia are of about the same size as those of the Lecideas, reaching middle size, though small and minute forms are somewhat more common in the present

genus. They are most commonly adnate, though sessile or somewhat immersed conditions are not unknown. The exciple is strictly lecideoid and frequently disappears. The disk is most commonly convex and varies in color from flesh color through various shades of brown to black. The hypothecium and the hymenium are usually more or less brownish, and the former may become quite dark. However, both may be pale in color. The paraphyses are essentially like those of the closely related genera, being commonly more or less coherent and simple, though branched forms may be looked for in any of the species. The asci differ slightly in that they are usually long-clavate or cylindrico-clavate. The spores are of the long slender form called acicular and are from 4 to 16-celled. Possibly the cells may rarely exceed this number, but the septa are frequently difficult to distinguish. Curved or twisted spore forms are common, and one end of the spore is usually wider and more rounded than the other. The species are very variable and difficult to determine or to differentiate in descriptions.

The spore characters relate the present genus most intimately to *Bilimbia*, while *Lecidea*, with its simple spores, stands at the opposite end of the series of closely related forms, with *Biatorella*, *Biatorina*, and *Bilimbia* as intermediate forms. And the external resemblance is so close in all of these genera that one can not always be sure even of the genus until the spores are examined.

A dozen species have been found in the State. On trees, and more rarely on rocks, moss, or earth.

Type species *Bacidia rosella* (Ach.) De Not. loc. cit.

KEY TO THE SPECIES.

- Apothecia reddish brown to brown, never black..... 2. *B. rubella*.
- Apothecia always or finally black.
 - Apothecia always black, minute, flat or finally convex.... 8. *B. akompsa*.
 - Apothecia becoming black.
 - Apothecia at first reddish.
 - Apothecia not flexuous, small, sessile, black..... 1. *B. atrosanguinea*.
 - Apothecia often flexuous.
 - Plants on trees; thallus of rather coarse greenish or brownish granules..... 11. *B. chlorantha*.
 - Plants usually on mosses; thallus a minute sea-green or whitish crust..... 9. *B. muscorum*.
 - Apothecia at first lighter or darker brown.
 - Apothecia at first pale brown.
 - Apothecia small or minute; plants commonly on rocks.
 - Spores hamate or spirally twisted..... 10. *B. umbrina*.
 - Spores not hamate nor spirally twisted... 6. *B. inundata*.
 - Apothecia middle-sized or larger; plants usually on trees.
 - Apothecia often with pruinose exciple... 3. *B. fuscorubella*.
 - Apothecia having the whole disk pruinose..... 3a. *B. fuscorubella suffusa*.
- Apothecia at first dark brown or darker.
 - Apothecia frequently flexuous.
 - Apothecia middle-sized, sessile or adnate, flattish, dark brown or black.... 4. *B. schweinitzii*.
 - Apothecia small or minute, commonly flat and adnate, black or blackish..... 7. *B. incompta*.

Apothecia never flexuous.

Apothecia soon convex, small, dark
brown to black..... 5. *B. endoleuca*.

Apothecia remaining flat or becoming
slightly convex, small or minute,
dark brown to black..... 12. *B. bacillifera*.

1. *Bacidia atosanguinea* (Schaer.) Anzi, Cat. Lich. Sondr. 70. 1860.

Lecidea anomala atosanguinea Schaer. Lich. Helv. Spic. 4: 170. 1833.

Thallus composed of minute granules, these usually contiguous and united into a roughened, chinky, or subleprose, widely spread, usually thin, ashy to sea-green crust, rarely disappearing; apothecia rather small, 0.2 to 0.85 mm. in diameter, sessile, flat with evident persistent exciple or rarely concave, or slightly convex, in ours black, but said to be sometimes dark reddish; hypothecium reddish-brown; hymenium pale below and pale brownish above; paraphyses simple or rarely branched, sometimes enlarged and darker toward the apex; asci cylindrico-clavate; spores several-celled, 30 to 50 μ long and 3 to 4.5 μ wide.

A single collection was made at Warroad. On trees.

Not known elsewhere in America. Well known in Europe.

Biatora atosanguinea of the preliminary reports.

2. *Bacidia rubella* (Hoffm.) Mass. Ric. Lich. 118. f. 231. 1852.

PLATE 5, B.

Verrucaria rubella Hoffm. Deutsch. Fl. 2: 174. 1795.

Thallus composed of minute scattered or crowned granules, frequently becoming compacted into a subleprose or more or less verrucose or chinky, sea-green, ashy, or rarely yellowish crust, irregularly and often widely spread over the substratum as a moderately thick or thinner layer, this sometimes becoming scattered and inconspicuous or disappearing entirely; apothecia small to middle-sized, 0.5 to 1.35 mm. in diameter, sessile or adnate, reddish yellow or reddish brown, flat with a rather thick and lighter-colored exciple, or becoming convex and the margin disappearing; hypothecium yellowish to brown; hymenium pale yellowish; paraphyses simple or rarely branched, sometimes slightly thickened and brownish toward the apex; asci long-clavate; spores several-celled (possibly sometimes as many as 16-celled), 45 to 65 μ long and 3 to 4 μ wide.

A form with pruinose margin is known as subspecies *porriginosa* (Turn.) Arn. Another with naked exciple is subspecies *luteola* (Schr.) Th. Fr. Ours is usually the latter. Th. Fries notes spores 100 μ long in European forms.

Generally distributed over the State. On trees.

The species is generally diffused in North America. The synonymy is somewhat uncertain, but the plant seems to occur in all of the grand divisions.

Biatora rubella of the preliminary reports.

EXPLANATION OF PLATE 5.—See page 71.

3. *Bacidia fuscorubella* (Hoffm.) Arn. Flora 54: 55. 1871.

Verrucaria fuscorubella Hoffm. Deutsch. Fl. 2: 175. 1795.

Thallus composed of rather coarser and less frequently scattered granules than the last, these forming a more conspicuous and commonly more widely spread, thicker, more rugose or chinky crust, more commonly continuous and rarely becoming scattered or tending to disappear, in color similar to the last; apothecia small to middle-sized, 0.6 to 1.5 mm. in diameter, sessile or adnate, flat, with an elevated and often transversely striate and pruinose exciple, less commonly becoming somewhat convex, the margin then disappearing, pale brown to darker and finally black; hypothecium yellow to brown; hymenium yellowish; paraphyses simple or rather rarely branched, commonly thickened and brownish toward the apex; asci long-clavate; spores about 7 to 14-celled, 40 to 75 μ long and 3 to 5 μ wide.

There are two subspecies of this plant, also, recognized in Europe, but scarcely to be distinguished in our material. The present species is on the whole better developed than the last and distinct from it, but the so-called subspecies *porriginosa* of the last is in some respects intermediate, as are other forms met in collecting.

Distribution in the State as general as that of the closely related *Bacidia rubella*. On trees and rarely on rocks.

North American distribution also as in the last. Well known in Europe and Asia and doubtless more widely distributed.

Biatora fuscorubella of the preliminary reports.

3a. *Bacidia fuscorubella suffusa* (Fr.) Fink.

Biatora suffusa Fr. Syst. Orb. Veg. 285. 1825.

Thallus quite similar to that of the last; apothecia on the whole larger, 1.75 to 2 mm. in diameter, with rather stouter exciple and the whole surface usually suffused with a white powder; internally like the last, except that the spores are slightly narrower, 2.5 to 3.5 μ wide.

No. 102 of Lichenes Boreali-Americani, collected at Fayette, Iowa, is the best representative generally distributed, though some of this is hardly the subspecies.

Reported from Mankato, Granite Falls, and Red Lake, but some of the material is doubtless not the subspecies. On trees.

Tuckerman credited the plant with probably the same North American range as the species, but considered the subspecies a distinct species. Known also in Europe, but further distribution can not be given in the present state of synonymy.

Biatora suffusa of the preliminary survey.

4. *Bacidia schweinitzii* (Tuck.) Fink.

Biatora schweinitzii Tuck. in Darl. Fl. Cestr. ed. 3. 447. 1853.

Thallus composed of rounded and often crowded or even heaped granules, these frequently compacted into a continuous or scattered and commonly widely spread, chinky or verrucose, sea-green to olivaceous crust, this thin and somewhat inconspicuous or sometimes thicker and better developed than in any of the preceding, sometimes becoming ash-colored; apothecia middle-sized or larger, 0.6 to 1.75 mm. in diameter, sessile or adnate, flat or slightly convex, commonly dark brown or black and becoming flexuous, the exciple rather thick and lighter-colored or of same color, frequently becoming quite flexuous; hypothecium yellowish to dark brown; hymenium pale to yellowish, or sometimes bluish or pale violet above; paraphyses simple or rarely branched, commonly thickened and darker toward the apex; asci long-clavate; spores about 7 to 15-celled, 40 to 70 μ long and 2.5 to 3.5 μ wide.

Collected in the Misquah Hills, on Oak Island, and at Harding. The plants from the second locality were unusually well developed, with conspicuous thallus and large apothecia and spores. On trees, especially cedars in swamps.

A strictly North American plant, distributed widely east of the Mississippi River, from the southern United States northward into British America.

5. *Bacidia endoleuca* (Nyl.) Kickx, Fl. Crypt. Fland. 1: 261. 1867.

Biatora luteola endoleuca Nyl. Nya Bot. Notis. 98. 1853.

Thallus composed of minute granules, these compacted into a thin, smoothish, chinky or finally chinky-verrucose, commonly widely spread, sea-green, ashy or rarely darker crust, rarely disappearing; apothecia small, 0.5 to 0.75 mm. in diameter, sessile or adnate, at first slightly concave with a somewhat elevated and thick exciple, but soon convex and immarginate, the disk and exciple blackish brown to black; hypothecium pale to reddish brown or brown; hymenium pale below and brownish or brownish-violet above; paraphyses simple or rarely branched, commonly thickened and darker above; asci long-clavate; spores most commonly about 8-celled (4 to 16, according to Fries), 30 to 65 μ long and 2.5 to 4.5 μ wide.

Collected at four or five localities in the northwestern portion of the State. On trees.

The plant is reported from widely separate portions of the United States and British America and may be looked for anywhere in North America, except perhaps in arctic regions. Known in all of the grand divisions except possibly Asia.

Biatora atrogrisea is the synonym of the preliminary reports.

6. *Bacidia inundata* (Fr.) Koerb. Syst. Lich. 187. 1855.

Biatora inundata Fr. Vet. Akad. Handl. 1822: 270. 1822.

Thallus composed of minute granules, these commonly compacted into a thin or rarely thicker, chinky or subareolate, commonly widely spread, continuous or more or less broken, sea-green, ashy, or darkening crust; apothecia small or minute, 0.3 to 0.7 mm. in diameter, adnate or rarely somewhat immersed, the disk at first flat and bordered by an exciple, but soon becoming convex and the exciple disappearing, pale brownish, brown, or finally black, the exciple at first lighter than the disk, sometimes more or less clustered; hypothecium pale to brown; hymenium pale or brownish; paraphyses simple or rarely branched toward the apex, there also usually enlarged and brownish, somewhat more coherent than in most species; asci clavate or long-clavate; spores 4 to 8-celled, 20 to 40 μ long and 1.5 to 2.5 μ wide.

Generally distributed in the State. On various rocks in moist places, and rarely on wood.

Throughout the United States east of the Rocky Mountains and northward to Newfoundland. Well known in Europe.

Biatora inundata of the preliminary reports.

7. *Bacidia incompta* (Borr.) Anzi, Cat. Lich. Sondr. 70. 1860.

Lecidea incompta Borr. in Sowerby, Engl. Bot. Suppl. 2: pl. 2699. 1834.

Thallus composed of very minute granules, these forming a continuous or more or less broken, widely spread, sometimes thicker and rugose or possibly even subareolate, or again thin and smooth or more or less mealy, lighter or darker sea-green crust, sometimes becoming obscure or disappearing; apothecia small or minute, 0.35 to 0.75 mm. in diameter, adnate or perhaps rarely sessile, flat, with a thin and frequently flexuous margin, but becoming convex, black or brownish black; hypothecium brownish to reddish brown (rarely pale); hymenium pale below and brownish above; paraphyses simple or rarely branched toward the apex, there frequently thickened and darker; asci long-clavate; spores in ours 4 to 12-celled, 18 to 35 μ long and 1.5 to 3 μ wide.

Collected on the northern boundary at Rose Lake and at Gunflint. On trees.

Known elsewhere in North America from New England and Illinois. Common in Europe and also reported from the Sandwich Islands.

Biatora incompta of the preliminary reports.

8. *Bacidia akompsa* (Tuck.) Fink.

Biatora akompsa Tuck. Syn. N. A. Lich. 2: 47. 1888.

Thallus composed of minute granules, these running together into a scurfy or more compact and chinky, smooth or rugose-verrucose, commonly widely spread, ash-colored crust; apothecia minute, 0.2 to 0.5 mm. in diameter, sessile or adnate, flat, with an uneven, thin margin, or later convex, black; hypothecium pale or brownish; hymenium pale or pale brownish below and the same or violet-tinged above; paraphyses simple or rarely branched toward the apex, there commonly enlarged and darker; asci cylindrico-clavate; spores scarcely more than 4-celled in ours, 19 to 24 μ long and 1.5 to 2.5 μ wide.

Collected at Battle Lake, Warroad, and Emo, all in the northwestern portion of the State. On trees.

A North American lichen, known elsewhere on the Pacific coast in California and on Vancouver Island.

Biatora akompsa of the preliminary reports.

9. *Bacidia muscorum* (Hoffm.) Fink.

Verrucaria muscorum Hoffm. Deutsch. Fl. 2: 191. 1795.

Thallus composed of minute granules commonly run together into a widely spread rugose-verrucose, usually well developed, sea-green or whitish crust; apothecia small to middle-sized, 0.4 to 1.2 mm. in diameter, sessile or adnate, flat, with a thin and frequently flexuous margin, or perhaps more commonly becoming convex and immarginate, frequently conglomerately clustered, black or rarely reddish brown; hypothecium yellowish to dark brown; hymenium pale yellowish, or violet-tinged above; paraphyses simple or rarely branched, frequently thickened and darker toward the apex; asci long-clavate; spores about 6 to 10-celled, 25 to 45 μ long and 2 to 3.5 μ wide.

Generally distributed over the State. On earth, over mosses, and rarely on bark.

Also in New England, New York, Illinois, Iowa, and Nebraska and northward to arctic America. Known likewise in Europe and Asia.

Biatora muscorum of the preliminary reports.

10. *Bacidia umbrina* (Ach.) Branth & Rostr. Bot. Tidssk. 3: 235. 1869.

Lecidea umbrina Ach. Lich. Univ. 183. 1810.

Thallus composed of minute granules, these commonly compacted into a thickish and continuous, or scattered and thinner, subleprose, chinky or subareolate crust; sea-green varying to ashy or even blackish, widely spread, the granules, when apparent, usually flattened, the whole thallus sometimes tending to disappear; apothecia minute, 0.25 to 0.6 mm. in diameter, adnate or somewhat immersed, at first flat, with a commonly paler margin, but becoming convex and immarginate, light brown to black; hypothecium pale brownish to brown; hymenium pale below and darker above; paraphyses simple or rarely branched, commonly enlarged and darker toward the apex; asci long-clavate or inflated-clavate; spores hamate or more or less spirally twisted, about 4 to 8-celled, 18 to 30 μ long and 2 to 3 μ wide.

Collected near Minneapolis. On calcareous rocks. Also a larger and doubtful form was collected on cedars in a swamp near Warroad. Doubtless occurs on rocks in other portions of the State, but very difficult to distinguish macroscopically from the more common *Bacidia inundata*.

Elsewhere in North America in New England, New Jersey, Virginia, North Carolina, Illinois, Iowa, Nebraska, and Labrador or Newfoundland. Known also in Europe and Asia.

Biatora umbrina of the preliminary reports.

11. *Bacidia chlorantha* (Tuck.) Fink.

Biatora chlorantha Tuck. Syn. Lich. N. E. 60. 1848.

Thallus composed of rather coarse and scattered granules, becoming flattened, and when more compacted forming a bright green or paler or even brownish, frequently chinky crust; apothecia small to middle-sized, 0.4 to 1.5 mm. in diameter, sessile, flat or slightly convex, dark reddish brown or more commonly black, the exciple thick, lighter-colored, often becoming flexuous; hypothecium pale or pale brownish; hymenium pale throughout or slightly darkened above; paraphyses commonly simple, sometimes slightly thickened and darker toward the apex; asci clavate or inflated-clavate; spores several-celled, 20 to 35 μ long and 2 to 3 μ wide, numerous (30 to 50) in each ascus.

A single collection was made at Beaudette. On balsams in a swamp.

A North American lichen known elsewhere in New England, New York, Ohio, Illinois, and Ontario.

Biatora chlorantha of the preliminary reports.

12. *Bacidia bacillifera* (Nyl.) Fink.

Lecidea bacillifera Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 82. 1861.

Thallus composed of minute granules forming a scattered or more or less continuous crust, this ashy to sea-green, frequently disappearing; apothecia small or minute,

0.3 to 0.8 mm. in diameter, sessile, black or brownish black, flat or slightly convex, the exciple of the same color and often disappearing; hypothecium colorless or slightly brownish (in ours dark brown); hymenium pale; paraphyses commonly simple with apices sometimes thickened and darker-colored; asci cylindrico-clavate; spores 4 to 8-celled, acicular or oblong-cylindrical, usually straight, 18 to 32 μ long and 2.5 to 4 μ wide.

In ours the apothecia are often clustered and usually strongly convex, the exciple commonly absent.

Collected at Tofte and not previously reported from Minnesota. On poplar bark.

Found elsewhere on the island of Cuba.

BUELLIA De Not. Giorn. Bot. Ital. 2¹: 195. 1846.

The thallus is crustose and variously granulose, verrucose, and areolate, rather more inclined to areolate conditions than are the similar thalli of *Lecideas* and seldom showing typically granulose conditions. Though the thallus is on the whole rather more conspicuous than in the genus just named, its minute anatomy commonly reveals the same rudimentary condition, the cellular cortex being absent or barely suggested in the sections. Neither can algal and medullary layers be distinguished. The thallus lies mainly above the substratum, to which it is attached by hyphal rhizoids. It is seldom of any considerable thickness, yet it is by no means so frequently evanescent as is the rather more rudimentary thallus of the *Lecideas* and some other closely related genera. The algal symbiont is a *Cystococcus*-like plant.

The apothecia are small or more rarely middle-sized, are circular or irregular in outline, and in position relative to the thallus vary from sessile to immersed conditions. The disk is commonly black and is flat or convex. The proper exciple is also commonly black macroscopically, but more usually dark brown in section, as is also the hypothecium. The exciple is very similar to that of the *Lecideas*, and species of the two genera appear so much alike externally that their separation in the field can be accomplished only after long acquaintance. The hymenium is commonly pale or pale brownish. The spores, as the genus is here limited, are typically brown and 2-celled (4-celled in a few forms admitted and indicated in the descriptions), and vary in form from oblong to ellipsoid. Decolorate conditions of spores are occasionally met with in the genus.

As to structure of the thallus and apothecia (exclusive of the spores) the genus seems nearest to *Lecidea* and *Rhizocarpon*, while the spore characters seem to indicate a relationship with such genera as *Rinodina* and *Physcia*. And while the relationship with *Lecidea* is on the whole much closer than that with *Rinodina*, the spores always serve to distinguish between the present genus and the *Lecideas*, while in spite of the usual presence of a well-defined thalloid exciple in *Rinodina*, it is by no means always easy to distinguish between *Buellias* and *Rinodinas*.

Some fourteen forms occur in the State. On trees, rocks, and old wood.

Type species *Buellia canescens* (Ach.) De Not. op. cit. 197.

KEY TO THE SPECIES.

Parasitic on other lichens, and no thallus discernible.

Exciple commonly disappearing; apothecia minute, black. 9. *B. parmeliarum*.

Exciple persistent or tardily disappearing.

Spores normal.

Spores 9 to 13 μ long and 3 to 6 μ wide..... 7. *B. saxatilis*.

Spores 10 to 18 μ long and 6 to 8 μ wide..... 8. *B. inquilina*.

Spores 4-celled.

Spores 10 to 16 μ long and 3 to 6 μ wide..... 10. *B. parasitica*.

Spores 21 to 28 μ long and 7 to 9 μ wide..... 11. *B. glaucomaria*.

Not parasitic on other lichens.

On rocks.

Thallus sea-green or ashy, flat-areolate; spores 9 to 16 μ long and 4 to 7.5 μ wide..... 1. *B. spuria*.

Thallus gray to brownish or reddish brown; spores 25 to 38 μ long and 11 to 17 μ wide..... 12. *B. badioatra*.

On trees or old wood.

Thallus usually sea-green or ashy.

Thallus commonly smooth, rarely areolate, thicker.

Spores normal; apothecia small to middle-sized..... 2. *B. parasema*.

Spores 3 or 4-celled; apothecia as above 2a. *B. parasema triphragmia*.

Thallus thin, scurfy or chinky.

Spores 8 in each ascus; apothecia minute and black..... 4. *B. myriocarpa*.

Spores 12 or more in each ascus; apothecia as above..... 4a. *B. myriocarpa polyspora*.

Thallus not sea-green.

Thallus whitish-ashy; spores 19 to 31 μ long and 7 to 11 μ wide..... 3. *B. dialyta*.

Thallus brownish-ashy.

Thallus verrucose and becoming areolate (rarely on rocks); spores 9 to 15 μ long and 4 to 7 μ wide..... 5. *B. turgescens*.

Thallus scurfy, granulate, or sorediate; spores 6 to 10 μ long and 2 to 4 μ wide.... 6. *B. schaereri*.

1. *Buellia spuria* (Schaer.) Arn. Flora 55: 291. 1872.

Lecidea spuria Schaer. Lich. Helv. Spic. 3: 127. 1827.

Thallus more or less roughened and areolate, the areoles small and flat or becoming more or less convex and commonly multiangular and black-edged, either scattered upon the conspicuous so-called hypothallus or crowded into a continuous crust, sea-green or more commonly ashy-gray; apothecia small, 0.4 to 0.8 mm. across, adnate or immersed, the disk black and flat or slightly convex, the exciple black and prominent or rarely disappearing; hypothecium dark brown; hymenium pale or slightly brownish, especially above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate or inflated-clavate; spores brown, ellipsoid or oblong-ellipsoid, frequently somewhat constricted at the septum, 9 to 16 μ long and 4 to 7.5 μ wide.

Collected in several places in the southwestern portion of the State. On rocks other than calcareous.

The plant has a wide North American distribution and is also known in Europe and Africa.

2. *Buellia parasema* (Ach.) Koerb. Syst. Lich. 228. 1855.

Lichen parasemus Ach. Lich. Suec. 64. 1798.

Thallus commonly continuous and smooth, but often becoming thicker and roughened, chinky and finally areolate, but even showing occasionally granulate conditions, sea-green, ashy, or darkening, or even yellowish, bordered more or less by a black margin, the so-called hypothallus, rarely scattered upon the substratum as in the last; apothecia varying considerably in size, sessile or rarely adnate or even more or less immersed in specimens having thicker thalli, the disk usually flat and surrounded by a thin black exciple or becoming convex when the exciple (as rarely) disappears, the

exciple often more or less flexuous; hypothecium dark brown; hymenium pale, often with a brownish cast; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci commonly clavate, but sometimes inflated-clavate or even tending toward cylindrical forms; spores brown, ellipsoid or oblong-ellipsoid, varying considerably in size, in ours 10 to 22 μ long and 5 to 10 μ wide, but such extreme sizes as 10 to 34 μ long and 5 to 12 μ wide credited to some of the European subspecies.

Found throughout the State and common in the well wooded portions. On trees and dead wood.

Generally distributed throughout North America. Known also in all the grand divisions, except possibly Asia.

2a. *Buellia parasema triphragmia* (Nyl.) Th. Fr. Nov. Act. Reg. Soc. Sci. Ups. III. 3: 327. 1861.

Lecidea triphragmia Nyl. Mém. Soc. Sci. Nat. Cherb. 5: 126. 1857.

Differs from the usual forms only in that the spores frequently show 3, 4, and even 6-celled conditions. Some of the largest spores reported in Europe belong to this subspecies.

Collected in the northeastern portion of the State at Gunflint and at Tofte. On trees. To be expected in any part of the State, but not common and easily overlooked in a macroscopic examination.

Rarely reported in North America, but the wide separation of the few stations indicates that the subspecies may be looked for wherever the species exists. Known also in all the grand divisions, its occurrence in Asia making it almost certain that the usual form of the species also occurs there.

3. *Buellia dialyta* (Nyl.) Tuck. Gen. Lich. 187. 1872.

Lecidea dialyta Nyl. Flora 52: 123. 1869.

Thallus thin or very thin, scurfy or granulose, or more or less compacted into a thin crust, white or ashy, irregularly spread over the substratum, said to rest upon a white so-called hypothallus; apothecia minute, 0.2 to 0.5 mm. across, sessile or adnate, the disk black and becoming slightly convex, the exciple thin and commonly disappearing; hypothecium dark brown; hymenium pale; paraphyses simple or rarely compound, frequently enlarged and brownish toward the apex; asci clavate; spores brown, fusiform-ellipsoid, 19 to 31 μ long and 7 to 11 μ wide.

Collected on pines at Two Harbors. Easily passed over for a condition of the last above.

Elsewhere in North America in New England, New York, and California. Not known in other grand divisions.

4. *Buellia myriocarpa* (Lam. & DC.) Mudd, Man. Brit. Lich. 217. 1861. FIGURE 11. *Patellaria myriocarpa* Lam. & DC. Fl. Fr. ed. 3. 2: 346. 1805.

Thallus thin and scurfy or compacted into a smoothish or chinky crust, this irregularly spread over small areas of the substratum and frequently becoming roughened-verrucose, sea-green, ashy, or even white, often disappearing; apothecia minute, 0.2 to 0.6 mm. in diameter, adnate, often numerous, the disk black and flat, or becoming somewhat convex, the exciple also black, thin, and often disappearing; hypothecium dark brown; hymenium pale, or pale below and brownish above; paraphyses simple or branched, usually enlarged and brown toward the apex; asci clavate; spores brown, ellipsoid or oblong-ellipsoid, sometimes slightly constricted at the septum, 7 to 15 μ long and 4 to 7.5 μ wide.

Generally distributed over the State. On trees and old wood.

Widely distributed in North America. Also known in all the grand divisions except Africa.

4a. *Buellia myriocarpa polyspora* Willey in Tuck. Syn. N. A. Lich. 2: 97. 1888.

Differs in having 12 to 24 spores in each ascus.

Collected in widely separated localities and no doubt generally distributed in the State. Habitat as above.

Elsewhere in North America in Massachusetts, Illinois, Wisconsin, and Iowa. Not known in other grand divisions, unless it proves to be the same as *Buellia dives* Th. Fr.^a

Buellia myriocarpa punctiformis (Hofim.) Mudd was reported from the northern portion of the State, but this is simply the condition of the species with thin and disappearing thallus, while subspecies *chloropolia* (Fr.) Th. Fr. is the form with thicker thallus.

5. *Buellia turgescens* (Nyl.) Tuck. Gen. Lich. 185. 1872.

Lecidea turgescens Nyl. Mém. Soc. Sci. Nat. Cherb. 5: 337. 1857.

Thallus verrucose and commonly areolate, or the swollen verrucae crowded into a more or less plicate crust; brownish ashy or rarely with a reddish cast, irregularly scattered over the substratum, the thallus in some of the rock specimens showing some suggestion of a cellular cortex; apothecia minute, 0.2 to 0.5 mm. in diameter, adnate or more or less immersed, the disk black or dark brown, flat or slightly convex, the exciple also black and sometimes disappearing; hypothecium dark brown; hymenium pale or perhaps more commonly brownish, especially above; paraphyses rarely branched, commonly thickened and brown toward the apex; asci clavate; spores ellipsoid, brown, 9 to 15 μ long and 4 to 7 μ wide.

Generally distributed over the State. On dead wood and also on rocks.

The rock form was recorded in the preliminary reports as *Buellia pullata* Tuck.

Elsewhere in North America in New England. Known also in Australia.

6. *Buellia schaeereri* De Not. in Giorn. Bot. Ital. 2^a: 199. 1846.

Thallus thin and scurfy, becoming granulose or sorediate-powdery, brownish-ashy, often disappearing; apothecia minute or very minute, 0.15 to 0.45 mm. in diameter, adnate, the disk black and flat or becoming variously convex, plicate or papillate, the exciple thin, brownish black, often disappearing; hypothecium dark brown, or rarely much lighter or only slightly colored; hymenium pale, or pale below and brownish above; paraphyses commonly cohering closely, enlarged and brownish toward the apex; asci short-clavate or inflated-clavate; spores brown, ellipsoid or oblong-ellipsoid, 6 to 10 μ long and 2 to 4 μ wide.

Collected only at Rainy Lake City, but easily overlooked and doubtless occurring elsewhere in northern Minnesota. On pines.

Elsewhere in North America in New England, New Jersey, New York, Illinois, and Ontario. Known also in Europe and Africa.

7. *Buellia saxatilis* (Schaer.) Koerb. Syst. Lich. 228. 1855.

Calicium saxatile Schaer. Naturw. Anzeig. Schw. Ges. 5: 35. 1821.

Parasitic, and no thallus discernible except that of the host; apothecia minute, 0.2 to 0.4 mm. in diameter, sessile on the thallus of the host or at first somewhat immersed, the disk flat and black or rarely becoming convex, the exciple brownish black, commonly elevated, persistent, rather thick; hypothecium dark brown; hymenium pale

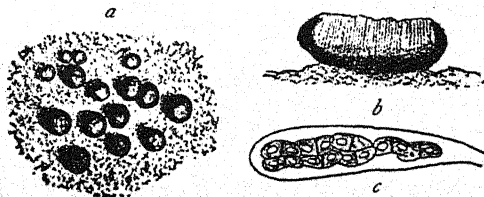


FIG. 11.—*Buellia myriocarpa*. a, Apothecium; b, vertical section of apothecium showing the dark exciple; c, ascus containing spores. a, Enlarged 4 diameters; b, 40 diameters; c, 450 diameters. From Reinke.

yellowish below and darker above in ours; paraphyses distinct or somewhat coherent, rarely branched, commonly enlarged and brownish toward the apex; asci clavate or narrowly clavate; spores brown, ellipsoid, 9 to 13 μ long and 3 to 6 μ wide.

Collected on the northern boundary at Rainy Lake City. On the thallus of *Baeomyces byssoides*.

Elsewhere in North America in Vermont and Newfoundland. Known also in Europe.

8. *Buellia inquilina* Tuck. Lich. Calif. 32. 1866.

Parasitic and no thallus discernible except that of the host; apothecia minute, 0.2 to 0.5 mm. in diameter, sessile or somewhat immersed, the disk black or brownish black, flat or somewhat convex, the exciple black and prominent or finally disappearing in ours; hypothecium dark brown; hymenium pale; paraphyses rarely branched, commonly thickened and brownish toward the apex; asci clavate; spores brown, ellipsoid, 10 to 18 μ long and 6 to 8 μ wide.

Collected at Warroad, on the northern boundary. On *Lecanora cinerea*, the host thus differing from that of Tuckerman, as likewise the plant differs somewhat in form and size of the apothecia.

Known elsewhere in Pennsylvania, North Carolina, South Carolina, and Texas. A strictly North American lichen.

9. *Buellia parmeliarum* (Sommerf.) Tuck. Syn. N. A. Lich. 2: 106. 1888.

Lecidea parmeliarum Sommerf. Suppl. Fl. Lapp. 176. 1826.

Parasitic, and no thallus discernible except that of the host, this commonly distorted and forming small tufts and lobules of unusual form, the color also often changed; apothecia minute, 0.2 to 0.5 mm. in diameter, the disk black or brownish black, flat or more commonly convex, the exciple prominent and black but commonly disappearing; hypothecium brown, varying toward blackish; hymenium pale to pale brownish below and brownish or brown above; paraphyses sometimes branched, commonly enlarged and brownish toward the apex; asci cylindrico-clavate; spores oblong-ovoid to ellipsoid, brown, 10 to 15 μ long and 3 to 6 μ wide.

Common in the northern portion of the State. On *Parmelia saxatilis* and *P. borrieri* on cedars in swamps.

Elsewhere in North America in New England, Nebraska, California, and Newfoundland, and at Bering Strait. Known also in Europe and Africa.

10. *Buellia parasitica* (Floerke) Tuck. Gen. Lich. 188. 1872.

Lecidea parasitica Floerke, Deutsch. Lich. no. 101. 1819.

Parasitic and showing no thallus except that of the host plant; apothecia minute, 0.2 to 0.6 mm. in diameter, sessile, the disk flat or rarely becoming slightly convex, black and oftener variously plicate when the apothecium becomes irregular in form, the exciple thin and rarely disappearing in the plicate and irregular forms; hypothecium dark brown; hymenium commonly pale below and brown or brownish above; paraphyses simple or rarely branched, frequently enlarged and brownish toward the apex; asci clavate; spores 4-celled, brown, ellipsoid or oblong, 10 to 16 μ long and 3 to 6 μ wide.

Collected in the northern part of the State at Oak Island, Harding, and Tower. On *Pertusaria communis* and *Lecanora pallescens*.

Also known in North America in California and Oregon, and at Bering Strait. Found also in Europe and New Zealand.

11. *Buellia glaucomaria* (Nyl.) Tuck. Syn. N. A. Lich. 2: 108. 1888.

Lecidea glaucomaria Nyl. Nya Bot. Notis. 177. 1852.

Parasitic and showing no thallus except that of the host plant; apothecia minute, 0.25 to 0.65 mm. in diameter, sessile, sometimes clustered and heaped, the disk flat and black, the exciple thick and seldom disappearing; hypothecium dark brown;

hymenium also commonly dark in section; paraphyses not distinctly seen in ours; asci clavate; spores 4-celled, brown, oblong-ellipsoid, 21 to 28 μ long and 7 to 9 μ wide.

Collected along the northern boundary at Warroad. On *Pertusaria* sp. on birch.

Elsewhere in North America in Greenland. Known also in northern Asia.

12. *Buellia badioatra* (Floerke) Koerb. Syst. Lich. 223. 1855.

Lecidea badioatra Floerke in Spreng. Neu. Entd. 2: 95. 1821.

Thallus verrucose or more commonly chinky-areolate, the areoles usually convex and wart-like, scattered upon the black so-called hypothallus or crowded and forming a continuous crust, varying in color from gray to brownish or reddish brown, irregularly and often widely spread over the substratum; apothecia small, 0.3 to 0.75 mm. in diameter, immersed and adnate, the disk flat or slightly convex, black, the exciple black, hardly raised above the disk and scarcely noticeable except in section; hypothecium dark brown; hymenium pale below and dark brown above; paraphyses coherent or becoming semidistinct, simple or rarely branched; asci clavate or inflated-clavate; spores brown, ellipsoid or oblong-ellipsoid, often somewhat constricted at the septum, 25 to 38 μ long and 11 to 17 μ wide, surrounded by a halo.

Collected on Blueberry Island in Lake of the Woods. On rocks. Externally quite like *Rhizocarpon petraeum*, of which it may yet prove to be but a 2-celled condition.

Elsewhere in North America in Greenland and Newfoundland. Known also in Europe.

The position of the species after the 4-celled species may well be questioned, but on the whole it seems nearest to *Rhizocarpon*.

RHIZOCARPON^a Ram. in Lam. & DC. Fl. Fr. ed. 3. 2: 365. 1805.

The thallus is commonly crustose, though tending toward squamulose conditions in one or two species, on the whole better developed than in *Buellia*, as shown in the more conspicuously verrucose and areolate conditions and the absence of granulose forms, but scarcely showing cellular cortex in any of the species, nor with distinguishable algal or medullary layers. It lies plainly above the substratum, to which it is attached by hyphal rhizoids, is on the whole considerably thicker and more conspicuous than the thalli of *Buellias*, and never entirely disappears, at least not in any of our species. The algal symbiont is as in *Buellia*.

In form, position relative to the thallus, color, and nature of the disk and exciple, the apothecia are much the same as in the *Buellias* and *Lecideas*, but they are on the whole rather larger. The spores are peculiar in that, while they usually become brown or blackish brown, they are often persistently colorless, so that we find the colorless and the brown spores in the same species and even in the same section, and often apparently the colorless ones quite as mature as the brown ones. The mature spores are 4-celled and muriform and usually surrounded by a halo. It remains to be demonstrated that the spores pass from a 2-celled condition to the muriform condition in any of the species placed here.

The present genus is closely related to *Buellia*, from which it has been separated on account of the spore characters, this being the more common method of European lichenists. The close relationship of the two genera is perhaps best seen in *Buellia badioatra*, which shows quite as many characters of the present genus. We have admitted to the genus *Buellia* two species with 4-celled spores rather than recognize as a third genus *Dactylospora* Koerb.^b

Nine species and subspecies occur in the State. On rocks.

Type species *Rhizocarpon geographicum* (L.) DC. loc. cit.

^aThe original spelling is followed.

^bSyst. Lich. 271. 1855

KEY TO THE SPECIES.

Thallus whitish or ashy.

Thallus inclined to rounded forms.

Apothecia frequently concentrically arranged; spores
22 to 39 μ long and 11 to 16 μ wide.....

3. *R. calcareum*
concentricum.

Apothecia not concentrically arranged; spores 12 to 22
 μ long and 4 to 9 μ wide

1a. *R. alboatrum*
saxicolum.

Thallus not inclined to rounded forms, but widely spread
and thin; spores as in the last above.....

1. *R. alboatrum.*

Thallus not whitish or ashy (except sometimes in *R. ignobile*).

Thallus from greenish to bright yellow.....

5. *R. geographi-*
cum.

Thallus from dark ashy to brownish black.

Apothecia immersed.

Spores always becoming muriform, rather large...

2a. *R. petraeum*
grande.

Spores rarely muriform, smaller.....

4. *R. ignobile.*

Apothecia not always immersed.

Apothecia immersed or adnate.

Spores 8 in each ascus.....

2. *R. petraeum.*

Spores 1 or 2 in each ascus.....

2b. *R. petraeum*
montagnaei.

Apothecia adnate or somewhat immersed.....

2c. *R. petraeum ob-*
scuratum.

1. *Rhizocarpon alboatrum* (Hoffm.) Th. Fr. Nov. Act. Reg. Soc. Sci. Ups. III.
3: 337. 1861.

Lichen alboater Hoffm. Enum. Lich. Icon. 30. 1784.

Thallus ashy-gray, whitish or white, commonly widely spread over the substratum as a continuous crust but sometimes scattered or rarely disappearing, at first smooth but becoming chinky and verrucose-areolate and even rarely mealy; apothecia rather small, 0.3 to 1 mm. in diameter, adnate or immersed, the disk dull black or more or less white-pruinose, flat or becoming convex, the exciple black and commonly disappearing; hypothecium blackish brown; hymenium pale or pale brownish below and darker above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores brown, 4-celled and becoming muriform, 12 to 22 μ long and 4 to 9 μ wide.

Quite common in the northwestern and southwestern portions of the State. On trees, especially elms.

Generally distributed throughout North America. Found also in Europe, Asia, and Africa.

Buellia alboatra of the preliminary reports.

1a. *Rhizocarpon alboatrum saxicola* (Fr.) Fink.

Lecidea alboatra saxicola Fr. Lich. Eur. 337. 1831.

Thallus thicker and more inclined to rounded forms upon the substratum.

Collected at Mankato and at Rainy Lake City. On limestone and igneous rocks.

Widely distributed in North America, but not yet reported from arctic regions.

Known also in Europe.

Buellia alboatra saxicola of the preliminary reports.

2. *Rhizocarpon petraeum* (Wulf.) Koerb. Syst. Lich. 260. 1855.

Lichen petraeus Wulf. in Jacq. Coll. Bot. 3: 4, pl. 6. f. 2a. 1789.

Thallus varying in color from dark ashy to sea-green and brownish or brownish black, smooth or more commonly more or less roughened, chinky, and verrucose-areolate, usually widely and irregularly disposed upon the substratum, and continuous or scattered upon the commonly distinct and black so-called hypothallus, varying considerably in thickness, the areoles or verrucae also varying in size in the various forms, but small or even minute; apothecia minute or middle-sized, 0.2 to 1.3 mm. in diameter, immersed or adnate, the disk black or blackish brown and flat or rarely somewhat convex, the exciple of the same color and at first elevated but frequently disappearing; hypothecium dark brown; hymenium pale or pale below and commonly brownish above; paraphyses commonly simple but sometimes branched, usually enlarged and brownish toward the apex; asci clavate or inflated-clavate; spores 4-celled and muriform, brown or hyaline, 15 to 40 μ long and 7 to 18 μ wide.

Occurring in all portions of the State except the southeastern. On igneous and metamorphic rocks.

Found throughout the northern portions of North America and well southward in the mountains. Known in all the grand divisions.

Buellia petraea of the preliminary reports.

The species varies greatly in the northern portion of the State, and in the last of the preliminary reports a number of subspecies were added on authority of A. Zahlbruckner and T. Hedlund. These forms are variously regarded by Europeans as species or subspecies, and the disposition and synonymy are in a hopeless tangle for the present. On the whole it seems best after further study to record some of the various forms here as subspecies of the above species without any hope of having made a final or even a clear disposition of all the difficulties.

2a. *Rhizocarpon petraeum grande* (Floerke) Fink.

Catocarpon grande Floerke, Flora 2: 690. 1828.

Thallus verrucose-areolate, the areoles swollen, ashy or violaceous brownish, usually scattered upon the conspicuous black hypothallus; apothecia immersed between the areoles, soon becoming very convex and subglobose; spores rather large.

Throughout the northeastern portion of the State and as far south as Taylors Falls. Habitat as above.

North American distribution the same as that of the species. Known also in Europe.

Buellia petraea grandis of the preliminary reports.

2b. *Rhizocarpon petraeum montagnaei* (Flot.) Fink.

Rhizocarpon montagnaei Flot.; Koerb. Syst. Lich. 258. 1855.

Thallus as above, but the spores only one or two in each ascus and of the largest size given for the species.

In all parts of the State where the species is known. Habitat as usual.

A strictly North American subspecies with same general range as the species.

Buellia petraea montagnaei of the preliminary reports.

2c. *Rhizocarpon petraeum obscuratum* (Ach.) Fink.

Lecidea petraea obscurata Ach. Lich. Univ. 156. 1810.

Thallus thin, minutely areolate with flat areoles, ashy or pale brownish, the hypothallus commonly poorly developed or absent; apothecia adnate or somewhat immersed, the exciple thick and persistent around the commonly flat disk; spores persistently hyaline or only slightly colored.

Collected at Kettle Falls. On rocks.

Elsewhere in North America in Newfoundland. Known also in Europe.

Buellia obscurata of the preliminary reports.

3. *Rhizocarpon calcareum concentricum* (Dav.) Th. Fr. Lich. Scand. 2: 632. 1874. PLATE 8, A.

Lichen concentricus Dav. Trans. Linn. Soc. Lond. 2: 284. 1794.

Thallus white or whitish, smoothish or becoming chinky and finally areolate with quite minute areoles, in ours frequently disposed in more or less circular areas upon the substratum, the areas not more than 3 to 5 cm. in diameter; apothecia frequently showing a well-defined concentric arrangement, said to be 1 to 1.5 mm. in diameter, but only 0.3 to 1 mm. in ours of this subspecies, immersed or adnate, the disk flat and dull black or dark brown, rarely whitish-pruinose, the exciple dull black and persistent; hypothecium dark brown; hymenium pale below and brownish above; paraphyses coherent or becoming distinct, simple or branched, thickened and brownish toward the apex; asci clavate or inflated-clavate; spores hyaline or brown, muriform in ours, said to be at first 4-celled, 22 to 39 μ long and 11 to 16 μ wide.

The suborbicular thallus and the concentric arrangement of the apothecia are the special marks of the subspecies and to this may be added that the disk is said to be sometimes concave.

Collected at Rainy Lake City and at Kettle Falls. On rocks. Also at Grand Marais, and not previously reported from this locality, where the likeness given herewith was secured.

Not known elsewhere in North America. Found also in Europe.

The material from Grand Marais, determined by T. Hedlund, is plainly marked, and distinct from any form of *Rhizocarpon petraeum*, but I am disposed to think that all the forms recorded in the preliminary reports as *Buellia concentrica* belong to that species.

EXPLANATION OF PLATE 8.—A, Plant of *Rhizocarpon calcareum concentricum* on rocks, showing the orbicular crustose thallus and the concentrically arranged apothecia. B, Plant of *R. geographicum* on rock, showing the areolate crustose thallus and the immersed apothecia. A enlarged $2\frac{1}{2}$ and B 3 diameters.

4. *Rhizocarpon ignobile* Th. Fr. Lich. Scand. 2: 619. 1874.

Thallus ashy or ashy brownish, chinky or minutely verrucose-areolate, continuous or scattered upon the black hypothallus, more or less circular in small areas or more widely and irregularly distributed over the substratum; apothecia commonly immersed, small or minute, 0.3 to 0.7 mm. in diameter, the disk dull black, flat or becoming convex, the exciple black and frequently disappearing; hypothecium dark brown; hymenium pale, or pale below and brownish above; paraphyses frequently cohering, simple or branched, commonly enlarged and brownish toward the apex; asci clavate or inflated-clavate; spores in ours most frequently 2-celled, but passing into 4-celled and rarely into muriform conditions, hyaline, 14 to 20 μ long and 6 to 11 μ wide.

Determined by A. Zahlbruckner from Grand Portage Island and not previously reported from Minnesota. On rocks. Also, the plant from Rainy Lake City recorded as *Buellia conereta* in the last preliminary report seems to belong here. This was also determined by Doctor Zahlbruckner.

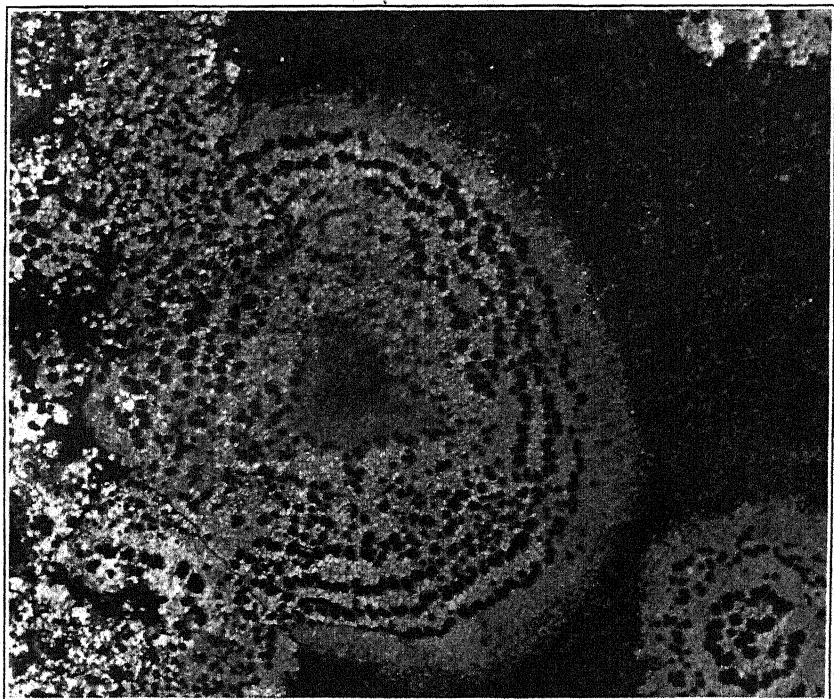
Rhizocarpon conereta is known from Newfoundland, but *R. ignobile* has not been previously reported from North America. Found also in Europe.

5. *Rhizocarpon geographicum* (L.) Lam. & DC. Fl. Fr. ed. 3. 2: 365. 1805.

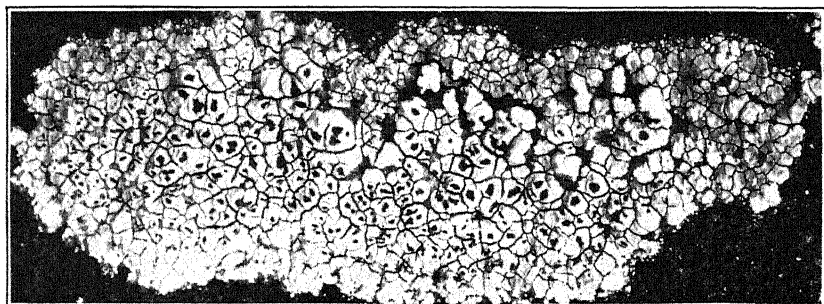
PLATE 8, B.

Lichen geographicus L. Sp. Pl. 1607. 1753.

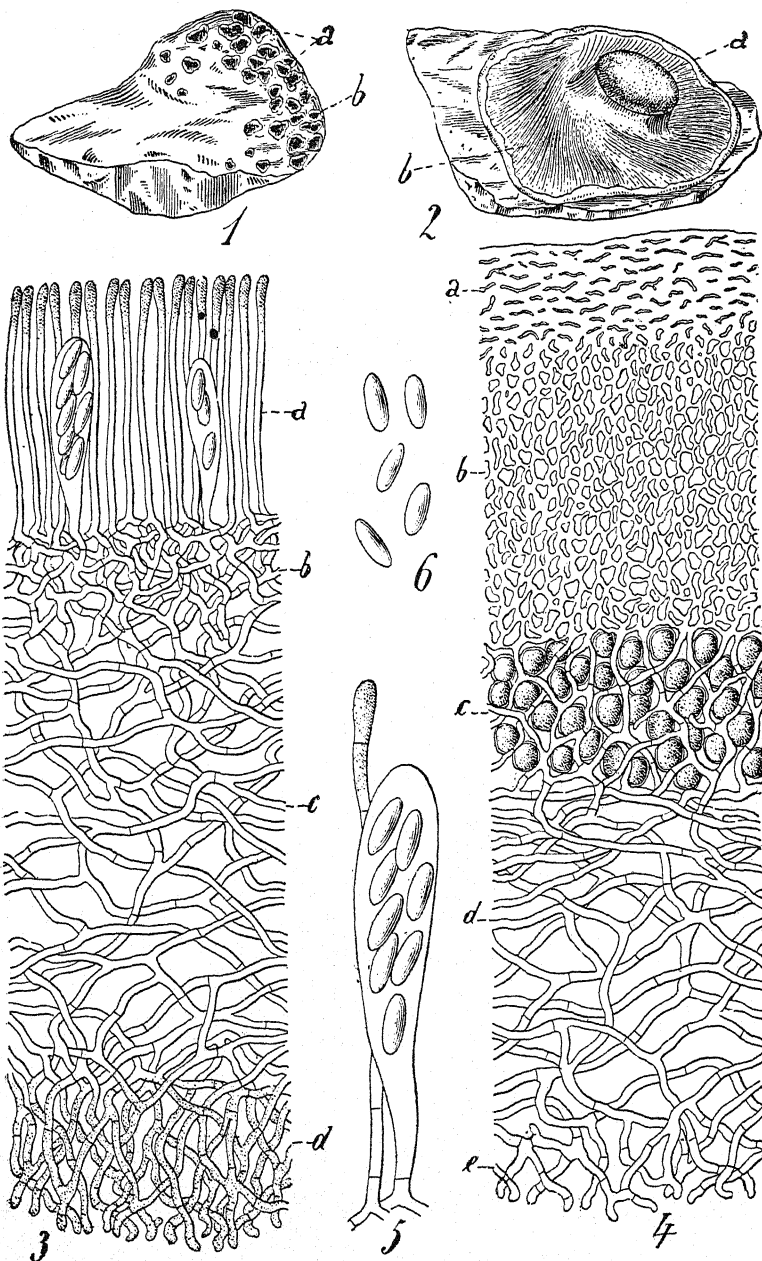
Thallus greenish to bright yellow upon a black hypothallus, composed of small areoles scattered over the substratum upon the conspicuous hypothallus or crowded into a continuous crust, in the latter case sometimes verrucose or chinky rather than distinctly areolate, the areas upon the substratum often quite small; apothecia small, 0.4 to 1 mm. in diameter, often crowded together in groups, and then angulate, in the more continuous forms of thalli immersed between the areoles or in the thallus, the disk black and flat or convex, the exciple black and somewhat prominent, but often disappearing; hypothecium dark brown; hymenium pale, or pale below and brownish



A. RHIZOCARPON CALCAREUM CONCENTRICUM (DAV.) TH. FR.



B. RHIZOCARPON GEOGRAPHICUM (L.) LAM.



PSORA RUSSELLII (TUCK.) FINK.

above; paraphyses distinct or cohering, sometimes branched and frequently thickened and brownish toward the apex; asci clavate or inflated-clavate; spores 2 to 4-celled and becoming muriform, hyaline to blackish brown, 18 to 38 μ long and 10 to 17 μ wide.

Occurring rarely in the extreme northern portion of the State. On rocks.

Throughout British America and Alaska and occasionally noted in the northern United States and southward in the mountains. Known in all the grand divisions.

Buellia geographica of the preliminary reports.

EXPLANATION OF PLATE 8.—See page 100.

Family PSORACEAE.

This is a small family closely related to the last. Indeed, it may well be doubted whether there is sufficient reason for separating the Psoraceae from the Lecideaceae. In the present family the thallus is squamulose or squamulose-crustose with a well-developed cellular cortex above, while in the Lecideaceae there is rarely any suggestion of a squamulose condition, and in these best states there is only rarely a suggestion of a cellular cortex, never one sufficiently developed to form a continuous layer.

The apothecia are similar to those of the last family, but there is never any thaloid exciple. The algal symbiont is *Cystococcus*. The spores do not show so wide a range of structure as in the Lecideaceae, the brown and muriform forms being wanting.

Externally the thalli resemble those of certain Dermatocarpons, but there is no close relationship between that genus and members of the present family.

Two genera and several species and subspecies of the family occur in the State, on rocks or earth. The first genus seems to stand between section *Biatora* and *Cladonia*, while the second is nearest to *Eulecidea*, except for the spores, which are nearer to those of *Bilimbia*.

PSORA Hoffm. Descr. Pl. Crypt. 1: 37. pl. 8. f. 1 (et seq.) 1790.

PLATE 9.

The thallus is composed of squamules, each of which is to be regarded as a small foliose structure. These squamules are of various forms and may be scattered or may be run together into a continuous crustose or foliose thallus. The upper cortex is well developed and thick and shows a more or less well-defined cellular structure in all of the species. The lower cortex may be entirely wanting, or there may be a pseudocortex of hyphae extending for most part in a horizontal direction. The algal layer is always well represented. When the pseudocortex is present on the lower side, it replaces the medullary layer. The upper cellular cortex is more or less gelatinized and the cell lumina correspondingly reduced, and the gelatinization may go so far as completely to obliterate the cellular structure, especially in the upper portion of the cortex. The algal symbionts are doubtless a form of *Cystococcus*. The color of the thallus varies greatly. The squamules are attached to the substratum by more or less numerous hyphal rhizoids; and they may be flat and closely attached throughout, or the margins may be ascendant.

The apothecia are variously disposed over the surface of the squamules and are rather small and adnate or sessile. The proper exciple is evanescent or soon overgrown in all of our species and is therefore seldom seen. The color is most commonly a brown or black. The hypothecium is usually more or less brown, and the hymenium pale or somewhat colored. The paraphyses are commonly simple, but branched forms may be found in any of our species. The spores are simple, ellipsoid in form, and hyaline.

In apothecial and spore characters the present genus is plainly most closely related to *Lecidea*, but the thallus is much better developed than in any member of that

genus and reminds one of that of *Toninias* and also of the primary thallus of most *Cladonias*. Thus the genus seems to be related below with *Lecidea* and above with *Cladonia*, probably having been derived from members of the former genus and perhaps leading up to certain ones of the latter.

Five species and subspecies occur in the State. Commonly on earth or rocks.

Type species *Psora caesia* Hoffm. loc. cit. But this is a *Physcia*, doubtless *P. caesia* (Hoffm.) Nyl. This, therefore, gives *Psora* precedence over *Physcia*, but *Psora* Hoffm. is anticipated by *Psora* Hill, 1769, a genus of *Asteraceae*.

EXPLANATION OF PLATE 9.—Fig. 1, *a*, a portion of the thallus; *b*, an apothecium. Fig. 2, *a*, an apothecium; *b*, a portion of the thallus. Fig. 3, a section through an apothecium and the underlying thallus; *a*, the hymenium; *b*, the hypothecium; *c*, the medullary layer; *d*, the hyphal rhizoids. Fig. 4, a section of the thallus; *a*, the dermis; *b*, the upper cortex; *c*, the algal layer; *d*, the medullary layer; *e*, the hyphal rhizoids. Fig. 5, a paraphysis and an ascus. Fig. 6, free simple spores. Fig. 1, natural size; fig. 2, enlarged about 8 diameters; fig. 3, enlarged 300 diameters; fig. 4, enlarged about 425 diameters; figs. 5, 6, enlarged 650 diameters. From Schneider.

KEY TO THE SPECIES.

Thallus brownish to blackish; on rocks.

Thallus brownish olivaceous and darker, ascendant..... 1. *P. rufonigra*.

Thallus dull brown to reddish brown, white-edged, adnate,
or ascendant at the margin..... 2. *P. russellii*.

Thallus not brownish or blackish; on earth.

Thallus white, adnate..... 3a. *P. decipiens debata*.

Thallus not white.

Thallus incarnate brick-colored, closely adnate, white-
edged..... 3. *P. decipiens*.

Thallus greenish yellow or finally tawny..... 4. *P. icterica*.

1. *Psora rufonigra* (Tuck.) Fink.

Biatora rufonigra Tuck. Syn. Lich. N. E. 58. 1848.

Thallus composed of brownish or more commonly olivaceous or even blackish, scattered or more or less clustered and imbricate, irregular or round-lobed, commonly ascendant, somewhat concave, smooth squamules, these rather small, 0.5 to 1.5 mm. in diameter, commonly darker along the margins and below, clothed below with dark hyphal rhizoids; below the algal layer of the thallus a layer of densely interwoven hyphae, to be regarded as a pseudocortex rather than a medulla; apothecia rather small, 0.3 to 1 mm. in diameter, adnate, in ours at least black, though said to be sometimes dark rufous, rarely flattish and margined by an exciple, but more commonly convex and immarginate; hypothecium pale; hymenium pale or darkening, especially above; paraphyses simple or rarely branched, commonly dark and enlarged toward the apex; asci clavate; spores oblong-ellipsoid, 8 to 15 μ long and 5 to 7 μ wide.

The plant is the most widely distributed member of the genus in the State, and may be looked for in all portions except the southeastern. On the Archæan or Algonkian rock exposures. Though the most widely distributed, this lichen is by no means common. Thus far, in Minnesota, it has always been met with growing on rocks with an alga resembling *Sirosiphon* in external appearance.

The species is widely distributed in the United States and extends northward into British America. A strictly North American plant.

Biatora rufonigra of the preliminary reports.

2. *Psora russellii* (Tuck.) Fink.

PLATE 9.

Lecidea russellii Tuck. Proc. Amer. Acad. 5: 417. 1862.

Thallus composed of rather thick, dull or reddish brown, scattered or more or less clustered, closely adnate or marginally ascendant, rounded or more or less lobed and

irregular, sometimes reticulately furrowed, white-edged squamules, larger than those of the above, 1 to 3.5 mm. in diameter, white beneath; pseudocortex below scarcely any, the hyphal rhizoids rather few, usually situated toward the center of the thallus; apothecia of about the same size as in the last, or perhaps somewhat larger, sessile, commonly convex and the paler margin disappearing, reddish brown and darkening; hypothecium yellowish or light brown; hymenium pale yellowish to brownish, lighter below; paraphyses simple, or rarely branched toward the commonly enlarged and brownish apex; asci cylindrico-clavate; spores ellipsoid, 9 to 13 μ long and 4 to 6 μ wide.

The plant here reported was collected at La Crosse, Wisconsin, by L. H. Pammel, but of course the same occurs on the Minnesota side. On calcareous rocks. Quite common in northeastern Iowa and no doubt also in southeastern Minnesota.

Widely distributed in the United States and northward into British America. A North American plant.

Biatora russellii of the preliminary reports.

3. *Psora decipiens* (Ehrh.) Hoffm. Descr. Pl. Crypt. 2: 63. *pl. 43. f. 1-3.* 1794.

Lichen decipiens Ehrh. in Hedw. Descr. Musc. Frond. 2: 7. 1789.

Thallus composed of incarnate brick-colored, scattered or rarely somewhat clustered, closely adnate, rounded or somewhat irregular and lobed, entire or in ours frequently delicately crenulate-margined, more or less concave and sometimes furrowed, white-edged squamules, which are thinner and somewhat smaller than those of the last, 0.75 to 3 mm. in diameter, and white below; thallus microscopically similar to the last; apothecia slightly smaller than in the last, 0.3 to 1.2 mm. in diameter, sessile or adnate, commonly marginal and sometimes oblong, brown and becoming black, usually strongly convex and the lighter margin absent; hypothecium brown or brownish; hymenium pale brownish or reddish brown; paraphyses simple or rarely branched toward the apex, there usually enlarged and brownish; asci clavate; spores oblong-ovoid, 10 to 16 μ long and 5 to 7 μ wide.

Collected at Granite Falls, at Battle Lake, and in the Leaf Hills. On calcareous earth. No doubt occurs also with the last in southeastern Minnesota, but always on earth. The differences between the present and the last species above are easily seen in the plants, though not easy to demonstrate in the descriptions.

Widely distributed in North America, but not known at the extreme south. Known from all the grand divisions except South America.

Biatora decipiens of the preliminary reports.

3a. *Psora decipiens dealbata* (Tuck.) Fink.

Biatora decipiens dealbata Tuck. Syn. N. A. Lich. 2: 13. 1888.

As the above, except that the thallus is white. It may well be doubted whether this should be recognized as a subspecies simply on the basis of the color difference.

Collected with the above at Granite Falls and in the Leaf Hills. The same occurs in Iowa and may be looked for wherever the species occurs.

Biatora decipiens dealbata of the preliminary reports.

4. *Psora icterica* (Mont.) Fink.

Biatora icterica Mont. Ann. Sci. Nat. Bot. II. 2: 373. 1834.

Thallus composed of greenish, yellowish, or finally tawny squamules, these scattered or areolately or imbricately clustered, closely adnate, but frequently somewhat raised and paler-edged, sometimes rounded but more frequently radiately or irregularly lobed, flat or concave, smooth or furrowed, ventrally white, 1 to 4 mm. in diameter in ours (Tuckerman says hardly so large as in the last); thallus showing the pseudocortex below much as in our first species of the genus; apothecia small to middle-sized, 0.3 to 1.2 mm. in diameter, closely sessile, dark brown and blackening,

the disk commonly convex and without margin; hypothecium pale brownish to brown; hymenium light brown; paraphyses simple or rarely branched, commonly thickened and brownish toward the apex; asci clavate; spores ovoid-ellipsoid, 12 to 18 μ long and 4 to 7 μ wide.

Collected at Granite Falls. Tuckerman also records the plant from the State, collected by Lapham, but without locality. On earth.

Widely distributed in the United States west of the Mississippi River, and also collected in New York and in British Columbia. A strictly American plant, also widely distributed in South America.

Biatora icterica of the preliminary reports.

TONINIA Mass. Ric. Lich. 107. f. 212-214. 1852.

The thallus is squamulose-crustose, squamulose, or even subareolate, and is usually lobed at the margin. So far as we have been able to examine the species, the upper cortex is rather thin, but cellular, and the algal and medullary layers are more or less differentiated. No lower cortex is developed. The upper cortex is usually considerably gelatinized and the cells may be completely obliterated, especially toward the upper portion. The algal symbiont is *Cystococcus*. White, ashy, sea-green, brown, and olivaceous are common colors. Hyphal rhizoids attach the thallus to the substratum. On the whole, the thalli remind one of those of the *Psoras*, and they may consist of scattered squamules or may be continuous with the squamules more or less imbricated. The apothecia are scattered over the squamules and are usually black, small, and adnate or sessile. The proper exciple is commonly dark, but may be lighter and more like that of the section *Biatora* than that of *Euleciea*. It usually soon disappears, leaving the apothecium without margin. The hypothecium varies from pale to dark brown and the hymenium also may be more or less brownish throughout. The asci are clavate or rarely cylindrico-clavate. The spores are hyaline, 4 to 8-celled, and oblong or ellipsoid.

The present genus is nearest to *Psora* as to thallus structure, but nearer to *Bilimbia* as to spores, and on the whole doubtless nearest to *Euleciea* as to character of the apothecium or more especially the exciple. Species having 2-celled spores are by some admitted to the genus, but we have followed Massalongi in excluding them.

A single species has been met in the State. On mossy rocks.

Type species *Toninia cinereovirens* (Schaer.) Mass. loc. cit.

Toninia aromatica (J. E. Smith) Mass. Symm. Lich. 54. 1855.

Lichen aromaticus J. E. Smith in Sowerby, Engl. Bot. 25: pl. 1777. 1807.

Thallus composed of rather small, contiguous or more or less scattered, verruca-like squamules, 0.5 to 2 mm. in diameter, when closely clustered forming a subverrucose crust, the squamules thickened and commonly more or less irregular, the crust, when continuous, somewhat irregular and covering areas of the substratum 10 to 35 mm. in diameter, olivaceous varying toward brownish or ashy; apothecia small, adnate, 0.4 to 1 mm. in diameter, often clustered, the disk black, at first flat and surrounded by the black exciple, soon becoming convex and variously irregular, the exciple disappearing; hypothecium brown to blackish brown; hymenium commonly brownish throughout and darker above; paraphyses simple or more or less branched, often somewhat coherent, commonly enlarged and brownish toward the apex; asci clavate or cylindrico-clavate; spores fusiform to cylindricofusiform, 4-celled, 15 to 27 μ long and 3 to 4.5 μ wide.

Collected on mosses over rocks at Grand Marais. Not previously reported from Minnesota.

Reported from California and Ontario, but the California material is said to have simple spores and must be immature or of some other species. Known also in Europe and Africa.



A. *BAEOMYCES BYSSOIDES* (L.) ACH.



B. *ICMADOPHILA AERUGINOSA* (SCOP.) MASS.

Family BAEOMYCETACEAE.

One of the two genera of this small group seems to stand out distinctly enough to warrant the recognition of the group as a family. This is the genus *Baeomyces*. Here we have a well developed stipe in company with apothecial characters related to those of the Lecideaceae rather than of the Caliciaceae, where the stipe is also found. It is apparent enough that the *Baeomyces* may have been evolved from the Lecideas by the development of a stipe. And, indeed, the relationship as to thallus, apothecia, and spores seems very close. But when we turn to the other genus, *Icmadophila*, we are confronted with difficulties which make it questionable whether that genus should be placed in the present family or with the Lecanoraceae. The relationships of the genus are discussed in connection with the description of it, and here it need only be said that the spore characters are such as might indicate a close relationship with *Biatorina* or *Bilimbia*, and that this fact adds weight to the present disposition of the genus.

The family is represented in the State by but two genera and as many species. Both species are found in the northern portion of the State.*

BAEOMYCES Ehrh. Beitr. Naturk. 4: 149. 1789.

The thallus is commonly crustose, though in one North American and a few foreign species it reaches a subfoliose condition. In all of the crustose species, at least, the cortical layers are absent, though algal and medullary layers may usually be distinguished, the former usually covered above by a thin layer of gelatinized hyphae. The hyphal rhizoids are few. The algæ are probably a modified form of *Cystococcus*, but *Gloeocapsa*-like colonies are also frequently found in some of the species. The apothecia are borne upon stipes, which are devoid of algal cells and thus more rudimentary structures than the podetia of the *Cladonias*. The stipes, accordingly, are composed entirely of hyphae, those forming the outside being closely packed and running longitudinally, while those toward the central portions are more loosely and irregularly arranged.

The apothecia are single or more or less grouped upon the stipes. They are surrounded by a proper exciple, which may disappear when the disk becomes very convex. The hypothecium is commonly pale and the hymenium pale or brownish below and darker above. The spores are simple and colorless in the genus as here limited.

The members of the genus are clearly related to the *Cladonias* and the *Lecideas*, and scarcely more closely or certainly with *Icmadophila*, which genus is included with *Baeomyces* by Tuckerman.

A single species is found in the State. On rocks and earth.

Type species *Lichen baeomyces* L. f. Suppl. Pl. 450. 1781. (*Baeomyces roseus* Pers. Ann. Bot. Usteri 7: 19. 1794.)

Baeomyces byssoides (L.) Ach. Lich. Suec. 82. 235. 1798.

PLATE 10, A.

Lichen byssoides L. Mant. Pl. 1: 133. 1767.

Primary thallus crustose and rather thin, granulose, the rounded granules becoming leprose-squamose and crenate-lobulate, commonly widely and irregularly spread over the substratum as a continuous or more or less broken crust, sea-green or more commonly varying toward greenish or whitish; stipes unbranched (or rarely divided above) and scarcely ever more than 3 or 4 mm. long, usually shorter and sometimes scarcely developed; apothecia commonly convex-pileate, small to middle-sized, 0.7 to 1.75 mm. in diameter, the disk from brownish flesh-colored to dark brown, the exciple evanescent; hypothecium commonly pale; hymenium pale brownish below and darker above; paraphyses simple or frequently branched, commonly enlarged

and darker toward the apex; asci cylindrico-clavate; spores simple, oblong-ellipsoid, 8 to 15 μ long and 3 to 4 μ wide.

Found in a number of places in the northern portion of the State. On rocks and earth.

Elsewhere in North America in New York, New Hampshire, Oregon, North Carolina, and Florida, and in several places in British America. Within the United States usually in mountains. Known also in South America, Europe, and New Zealand.

EXPLANATION OF PLATE 10.—A, Plant of *Baeomyces byssoides* on rocks, showing the thallus and the stipes surmounted by apothecia. B, Plant of *Icmadophila aeruginosa* on a decorticated log, showing the thallus and the apothecia. A enlarged nearly 2½ diameters; B enlarged nearly 2½ diameters.

ICMADOPHILA Ehrh. Beitr. Naturk. 4: 147. 1789.

In the single species known the thallus is crustose, usually widely spread over the substratum, to which it is closely attached, and scarcely showing any differentiation into layers. The algal symbiont is a modified form of *Cystococcus*, though *Gloeocapsa* may also appear in the association. The stipes are absent or very short, and if to be regarded as stipes at all, are solid throughout.

The apothecia are sessile or subsessile, of good size, and surrounded by a proper exciple, which may disappear. The proper exciple is in turn surrounded by a thalloid one, which is quite evanescent. The spores are 2 to 4-celled, hyaline, and fusiform.

The relationships of the genus are by no means certain. A comparison of the above description with that of *Baeomyces* will reveal considerable similarity, and yet perhaps the spore and apothecial characters would place the present genus quite as close to *Haematomma*. Also, the external resemblance to *Lecanora pallida* is very marked.

Type species *Lichen icmadophilus* L. f. Suppl. Pl. 450. 1781. (*Icmadophila aeruginosa* (Scop.) Mass.)

Icmadophila aeruginosa (Scop.) Mass. Ric. Lich. 26. 1852.

PLATE 10, B.

Lichen aeruginosus Scop. Fl. Carn. ed. 2. 2: 361. f. 42. 1772.

Primary thallus crustose, of medium thickness, roughened-granulate or rather verrucose, rarely becoming subleprose, usually widely spread over the substratum as a continuous crust, sea-green, varying toward greenish or whitish; apothecia sessile or borne on the rarely developed, very short stipes, middle-sized or larger, 0.6 to 3.5 mm. in diameter, rosy flesh-color or lighter, the disk flattish and commonly more or less wrinkled, surrounded by a rather thin proper margin, this in turn usually by more or less of a thalloid one, or the disk sometimes becoming convex and the excipular margin disappearing; hypothecium pale; hymenium of the same color or slightly darker above; paraphyses simple or rarely branched, sometimes slightly enlarged and colored above; asci cylindrico-clavate; spores oblong-fusiform, 2 to 4-celled, 14 to 28 μ long and 4 to 6 μ wide.

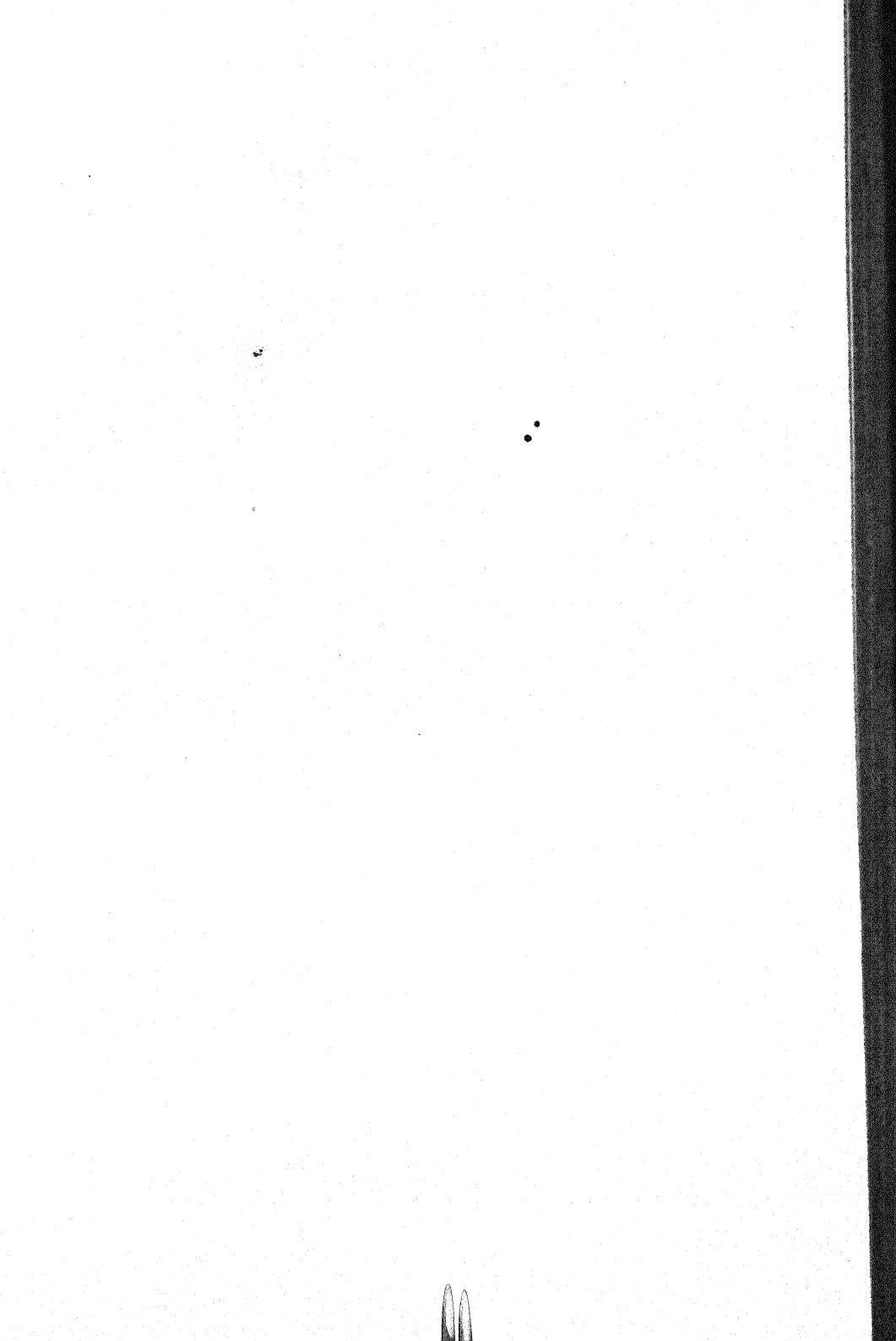
Generally distributed in the extreme northern portion of the State. On rotting wood.

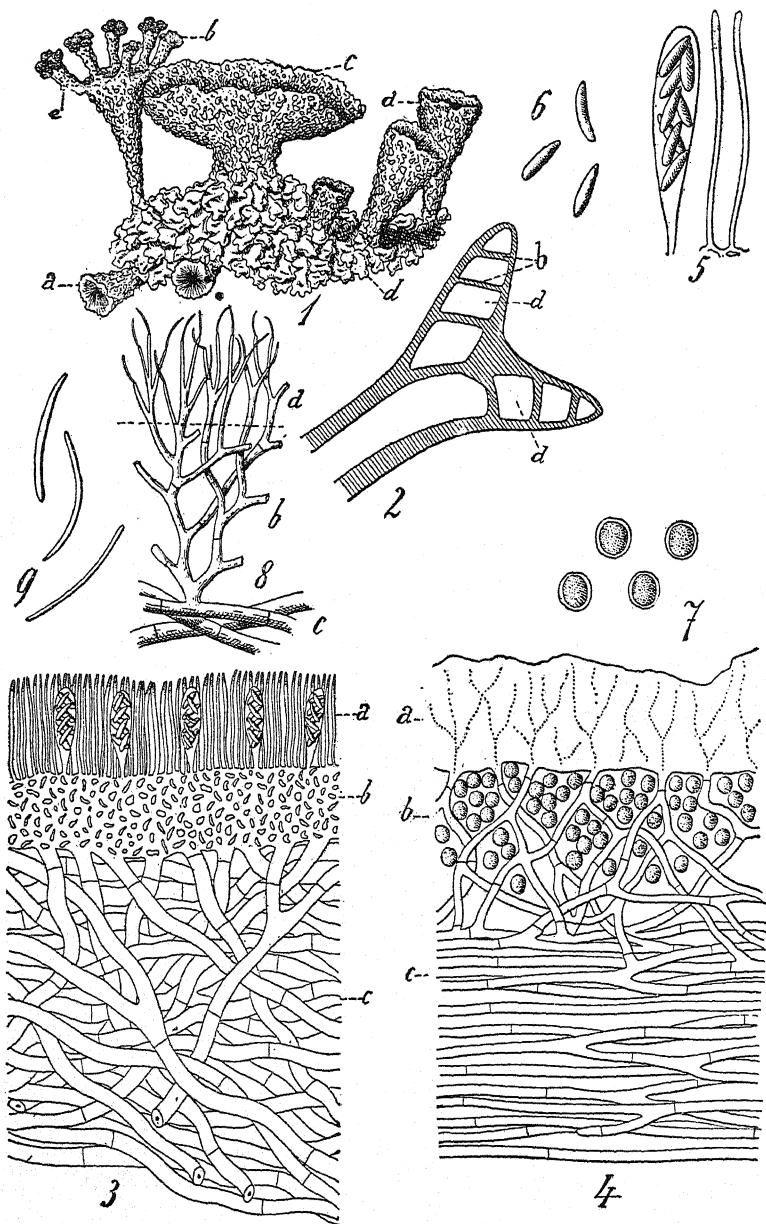
Found throughout British America, in Oregon, and in the Rocky Mountains. Known also in Europe and Asia.

Baeomyces aeruginosus of the preliminary reports.

Family CLADONIACEAE.

The family within the limits of this volume consists of the single genus *Cladonia*. The structure of the thallus and apothecia will be thoroughly discussed in the description of the genus. The origin of stipes and podetia is similar in each ontogeny, and it may be assumed that the lichens showing the podetia have been derived phylogenetically from some such genus as *Baeomyces*, in which we have the stipes and also





CLADONIA PYXIDATA (L.) HOFFM.

very similar apothecial structure. Hence it would seem that the *Cladonias* are closely related to *Baeomyces*. Plainly enough *Stereocaulon* is also closely related to *Cladonia*, and we need not discuss here several other closely related genera not found in our flora.

Though the family consists of the single genus, this genus is the largest in our flora and contains nearly one-eighth of all of our lichens.

CLADONIA Hill; Web. in Wig. Prim. Fl. Hols. 90. 1280.

PLATE 11.

The thallus consists of a basal more or less ascendant and squamulose primary portion and an erect fruticose portion, constituting the podetia. The basal or primary thallus may depart from the typical foliose and ascendant form, being then crustose and horizontal, and when so is more or less roughened or verrucose. In structure, this portion of the thallus shows a pseudocortex on the upper side, but the lower side is without cortex and usually sorediate; or more rarely the cortex is wanting even above. This primary thallus consists of squamules which are exceedingly variable in form and size even in a given species, and it may be evanescent, so that it is seldom seen in such long-lived plants as *Cladonias*. The algal and medullary layers are usually more or less differentiated.

The podetia commonly arise from the surface of the squamules or verrucæ of the primary thallus, though the primary thallus may disappear and even the bases of the podetia die while the upper portion continues to grow, perhaps for centuries. These podetia may be simple and cylindrical, tubæform, trumpet-shaped, or variously irregular, or they may be branched and are frequently very much so. Their summits are frequently cup-shaped, and from the margins or central portions of the cups secondary podetia may arise, and from the cups of these tertiary, etc. These secondary and tertiary podetia are commonly called proliferations, and the lowest and original podetia form the first rank, the secondary podetia the second rank, the tertiary the third rank, etc. The podetia are thus in the form of more or less hollow cylinders and have the usual layers arranged radially. In both primary thallus and podetia the cortex is really a pseudocortex of interwoven and much gelatinized hyphæ, and in the podetia algal cells are few. The cortex may be partly or entirely absent from the podetia, when they are likely to be sorediate. When present, the cortex may be continuous, verrucose, areolate, or scattered-areolate. Squamules similar to those of the primary thallus frequently clothe the podetia to a greater or less extent. The central hyphæ of the podetium run approximately in the direction of the long axis. The algal symbiont is *Cystococcus*. As to attachment, hyphal rhizoids are more or less frequent, fastening the squamules, or perhaps rarely the basal end of the podetia, to the substratum. The squamules, and more especially the podetia, in these recently evolved lichens are so extremely variable that the *Cladonias* become the most difficult lichens to determine.

The apothecia are either terminal on the podetia or on their cups or branches, or short apothecial stalks may intervene. They vary considerably in size, form, and arrangement, and may have a flat disk and a thin biatoroid margin, or a convex disk which is commonly without a marginal exciple. The prevailing color of the disk is brown or scarlet, and the upper portion of the hymenium usually partakes more or less of these colors, while the lower portion and the hypothecium are paler. The paraphyses are simple or more rarely branched, and the asci are clavate or cylindric-clavate, with the apical wall almost uniformly more or less thickened. The spores are simple, hyaline, ellipsoid, and so uniform in size and shape that no use is ordinarily made of them in the classification of species. Soredia are very common, though inconspicuous and easily overlooked.

The genus is closely related, as already noted, to *Stereocaulon*; also to *Thamnia*, a genus consisting of a single species and not represented in our flora.

Cladonia is represented in the State by over 50 more or less distinct lichens. Our species occur on all sorts of substrata, but most commonly on earth or old wood.

The synonymy of the Cladonias was considerably changed during the progress of the preliminary reports, and is consequently quite different in the earlier papers of these reports from that used in this volume.

Type species *Cladonia polymorpha* Web. loc. cit. (*C. squamosa* (Scop.) Hoffm.)

EXPLANATION OF PLATE 11.—Fig. 1, the plant; *a* and *c*, sterile podetia; *b*, apothecia; *d*, the primary thallus; *e*, proliferations or branches. Fig. 2, a diagrammatic section of the cup of a podetium; *a*, cavities; *b*, mechanical tissue. Fig. 3, a section of an apothecium; *a*, the hymenium; *b*, the hypothecium. Fig. 4, a section of the primary or horizontal thallus; *a*, the cortex of gelatinized hyphae; *b*, the algal layer; *c*, the hyphae extending in the direction of growth, within a very thin medullary layer between *b* and *c*. Fig. 5, two paraphyses and an ascus with spores. Fig. 6, spores. Fig. 7, algal cells. Fig. 8, *a*, sterigmata, bearing spermatia; *b*, hyphal network below the sterigmata; *c*, tissue inclosing the spermatogonium. Fig. 9, spermatia. Fig. 1, natural size; fig. 2, enlarged about 15 diameters; fig. 3, enlarged 250 diameters; fig. 4, enlarged about 175 diameters; figs. 5-7, enlarged 650 diameters; fig. 8, enlarged 500 diameters; fig. 9, enlarged 1,600 diameters. From Schneider.

KEY TO THE SPECIES.

Section I. Plants large, the primary thallus disappearing; podetia much branched; apothecia rare.

Podetia large, sea-green to grayish or brownish, the sterile tips

nutant..... 1. *C. rangiferina*.

Podetia hardly so large.

Podetia stoutish, whitish, straw-colored, or sea-green..... 2. *C. sylvatica*.

Podetia more slender, whitish or yellowish straw-colored,

the sterile tips erect and brighter..... 3. *C. alpestris*.

Section II. Apothecia scarlet; podetia usually not conspicuously branched.

Cups present and well developed.

Primary thallus usually disappearing; podetia usually

longer and more slender than in the three following... 8. *C. deformis*.

Primary thallus usually persistent.

Squamules large..... 6. *C. digitata*.

Squamules much smaller.

Podetia corticate throughout..... 7. *C. coccifera*.

Podetia decorticate and sorediate toward the top..... 7a. *C. coccifera pleurota*.

Cups absent or poorly developed.

Podetia absent or short..... 9b. *C. cristatella paludicola*.

Podetia well developed.

Podetia simple or rarely branched, usually decorticate.

Spores obliquely disposed; podetia rarely branched... 4. *C. bacillaris*.

Spores irregularly disposed; podetia more often branched..... 5. *C. macilenta*.

Podetia somewhat more commonly and conspicuously branched, corticate.

Podetia not densely squamulose..... 9. *C. cristatella*.

Podetia densely squamulose..... 9a. *C. cristatella vestita*.

Section III. Apothecia brown; primary thallus usually evanescent; podetia for the most part conspicuously branched.

Podetia more or less decorticate and sorediate..... 12a. *C. furcata scabruscula*.

Podetia corticate.

Podetia straw-colored, whitish, or sea-green.

Podetia not conspicuously squamulose, at least not throughout.

Tips straight and subulate.

Tips usually brown..... 10. *C. amaurocraea*.

Tips rarely brown.

Tips usually subulate; podetia stout..... 11. *C. uncialis*.

Tips short and obtuse; podetia stout..... 11a. *C. uncialis obtusata*.

Tips often recurved; podetia longer and more slender.. 12. *C. furcata*.

Podetia usually more or less squamulose throughout.

Tips and whole branches irregular..... 12c. *C. furcata finkii*.

Tips and branches not irregular..... 12d. *C. furcata pinnata*.

Podetia not always straw-colored or sea-green.

Podetia brownish or olive-brown above..... 12b. *C. furcata paradoxica*.

Podetia sea-green to reddish brown or olivaceous..... 13. *C. erispata*.

Section IV. Apothecia brown; primary thallus usually persistent; podetia for most part simple, or little branched.

Podetia becoming long.

Podetia always corticate.

Cortex continuous or closely areolate.

Podetia usually cupless; tips short-branched..... 19. *C. turgida*.

Podetia cup-bearing.

Proliferations from the centers of the cups..... 25. *C. verticillata*.

Proliferations in part from the margins of the cups and the sides of the podetia..... 25a. *C. verticillata cericornis*.

Cortex continuous to scattered, areolate.

Podetia sorediate between the scattered areoles.

Podetia sometimes squamulose toward the base, commonly cup-bearing..... 23. *C. gracilis*.

Podetia squamulose throughout; cups more irregular..... 23a. *C. gracilis dilacerata*.

Podetia subtomentose between the scattered areoles,

middle-sized, cylindrical or turbinate, sometimes

squamulose and often cup-bearing..... 24. *C. degenerans* and two subspecies, a and b.

Podetia not always corticate.

Podetia frequently becoming partly or almost wholly decorticate.

Podetia plainly squamulose.

Squamules small..... 15. *C. squamosa*.

Squamules larger..... 15b. *C. squamosa phyllocoma*.

Podetia not plainly squamulose.

Podetia almost destitute of squamules..... 15a. *C. squamosa multibracteata*.

Podetia squamulose-scaly..... 14. *C. subsquamosa*.

- Podetia always partly or wholly decorticate.
 Tips of podetia often perforate when not cup-bearing.... 18. *C. cenotea*.
 Tips of podetia not perforate.
 Podetia not cup-bearing.
 Podetia variously decorticate and sorediate..... 22. *C. decorticata*.
 Podetia wholly decorticate and sorediate, or corticate toward the base..... 27e. *C. fimbriata subulata*.
 Podetia frequently cup-bearing..... 27. *C. fimbriata* and subspecies below.
 Podetia short; cups common..... 27a. *C. fimbriata simplex*.
 Podetia longer.
 Cups common and well developed.
 Cups copiously and repeatedly proliferate.... 27b. *C. fimbriata proliferata*.
 Cups not so copiously proliferate..... 27d. *C. fimbriata radiata*.
 Cups absent or poorly developed.
 Podetia much elongated..... 27c. *C. fimbriata cornutoradiata*.
 Podetia not so much elongated.
 Podetia still quite long..... 27f. *C. fimbriata nemoxyna*.
 Podetia shorter.
 Podetia quite stout and not often squamulose..... 27g. *C. fimbriata coniocraea*.
 Podetia more slender and more frequently squamulose..... 27h. *C. fimbriata apo-lepta*.
 Podetia shorter.
 Podetia very short.
 Podetia abortive, decorticate..... 16. *C. caespiticia*.
 Podetia always evident, partly decorticate..... 17. *C. delicata*.
 Podetia somewhat longer.
 Podetia not cup-bearing.
 Podetia corticate throughout.
 Podetia simple or branched toward the apex..... 20. *C. mitrula*.
 Podetia freely branching, often from the base..... 21. *C. cariosa*.
 Podetia decorticate, at least toward the top..... 28a. *C. pityrea sub-
 acuta*.
 Podetia cup-bearing, at least sometimes.
 Cups not very commonly present.
 Cups rarely and abortively present..... 29. *C. botrytes*.
 Cups more often present..... 28. *C. pityrea*.
 Cups always present.
 Squamules of the primary thallus thinner and more incised.
 Podetia corticate throughout..... 26. *C. pyxidata*.
 Podetia decorticate above..... 26a. *C. pyxidata chlorophaea*.
 Squamules of the primary thallus thicker and less incised, closely packed into a brownish or olivaceous crust..... 26b. *C. pyxidata pocillum*.



CLADONIA RANGIFERINA (L.) WEB. (REINDEER MOSS.)

1. *Cladonia rangiferina* (L.) Web. in Wig. Prim. Fl. Hols. 90. 1780. PLATE 12.
Lichen rangiferinus L. Sp. Pl. 1153. 1753.

Primary thallus rarely seen, when present crustose and delicate and composed of subglobose, depressed or irregular, clustered or scattered verrucæ, these 0.25 to 0.4 mm. in diameter, ashy-white and destitute of cortical layer; podetia arising from the surface of the verrucæ, often as branches of old or dying podetia or from free fragments of old podetia, dying at the base, 3 to 20 cm. long and 0.7 to 3 mm. in diameter, subcylindrical and cupless, subdichotomously or subradiately branched, the short branches usually unilaterally deflexed and their axils somewhat dilated or frequently perforate, the apices subulate or furcellate, clustered or subsolitary among other lichens and mosses, erect or rarely ascending or even decumbent, the sterile apices commonly nutant and often brownish, the remainder of the podetium sea-green, varying toward gray or grayish brown; apothecia small, 0.5 to 2 mm. in diameter, solitary or clustered at the apices of the branches, immarginate, convex, commonly brown; hypothecium pale or the subhymenial portion brownish; hymenium brownish, or pale below; paraphyses frequently somewhat gelatinized, usually simple, the apex commonly somewhat thickened and brownish; asci cylindrico-clavate.

Generally distributed over the State, but common only in the northern part, where it reaches its largest size. The largest of our *Cladonias* and one of our most beautiful lichens. On earth, which frequently consists only of a thin layer of humus over rocks, or in crevices between rocks; also on old wood in a more or less depauperate condition. Especially common under pines or other conifers.

Widely distributed in North America. Quite general also in its foreign distribution.^a

EXPLANATION OF PLATE 12.—Plant on earth, portion of a cluster 45 cm. broad. One-fourth natural size.

2. *Cladonia sylvatica* (L.) Hoffm. Deutsch. Fl. 114. 1795.
Lichen sylvaticus L. Sp. Pl. 1153. 1753.

Primary thallus rarely seen, when present crustose, delicate, and composed of subglobose clustered or scattered verrucæ, these 0.12 to 0.48 mm. in diameter, straw gold-colored, destitute of a cortical layer; podetia without cortex, commonly formed from branches of old or dying podetia or rarely arising from verrucæ of the primary thallus, dying at the base, 3 to 15 cm. long and 0.5 to 3 or 4 mm. in diameter, cylindrical or subcylindrical, cupless, often somewhat dilated in the axils, dichotomously or finally sympodially or radiately branched, one or two radii becoming large and erect, the others remaining short and usually unilaterally or irregularly fasciculate and deflexed, the upper branches not much shortened and forming loose clusters, the apices subulate and very minutely radiate or furcate-spinose, the upper ones especially often brownish or brown; growing in clusters or subsolitary among other lichens and mosses, erect or rarely ascending or decumbent, the upper sterile apices often more or less nutant, the axils frequently perforated, often minutely webby tomentose, whitish or yellowish straw-colored or sea-green; apothecia small, 0.5 to 1.2 mm. in diameter, corymbose, solitary or clustered at the apices of the branches, having a thin margin or immarginate, convex or depressed-convex, brown or possibly varying toward brick red; hypothecium pale or the subhymenial portion brownish; hymenium brown or brownish above and brownish or pale below; paraphyses usually simple, commonly thickened and brownish toward the apex; asci clavate.

Occurs with the last and frequently mixed with it in the same clusters; even more rare in the southern portion of the State. Clusters frequently as large as those of the last.

American and foreign distribution quite as general as that of the last.

^a This is the "reindeer moss." For economic use see p. 34.

3. *Cladonia alpestris* (L.) Rabenh. Clad. Eur. Exsicc. pl. 39. no. 11. 1860.

FRONTISPIECE. PLATE 13.

Lichen rangiferinus alpestris L. Sp. Pl. 1153. 1753.

Primary thallus rarely present, crustose, delicate, consisting of subglobose or irregular, clustered or scattered verrucæ, these 0.16 to 0.30 mm. in diameter, straw-colored and destitute of a cortical layer; podetia arising from the verrucæ of the primary thallus, often springing from old or dying podetia or from free fragments of dying podetia, dying away at the base, 5 to 20 cm. long and 0.5 to 2.5 mm. in diameter, subcylindrical, often somewhat dilated in the axils, cupless, rarely somewhat subdichotomously or more commonly radiately or fasciculately branched, frequently with 4 to 6 branches surrounding a perforation in the axil, one branch or often more becoming larger and erect, the others remaining shorter and becoming finally unilaterally fasciculate and deflexed, the upper branches shortened, forming dense thyrses, the apices subulate or slightly radiately spinose; for the most part straight, clustered, erect, ecorticate, whitish or yellowish straw-colored, the apices often brighter; apothecia small, 0.3 to 0.5 mm. in diameter, disposed in dense corymbs at the apices of the branches, solitary, clustered, or confluent, thinly margined or immarginate, usually convex, light or darker brown; hypothecium pale; hymenium brownish above and pale or pale brownish below; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate to cylindrico-clavate.

Occurs with the last two species and frequently in the same cluster with one or both of them; more beautiful than either in its color, in the delicacy of its branching, and in the arrangement of its clusters. Quite common in the northern portion of the State, but not known to exist in the southern half.

American and foreign distribution quite similar to that of the last two, but though all three prefer cold regions, this species is more nearly confined to such territory than either of the others.

EXPLANATION OF FRONTISPIECE.—Plant on earth in woods. From a specimen found at Grand Portage, Minn. One-fourth natural size.

EXPLANATION OF PLATE 13.—Plant on earth, part of a cluster 60 cm. broad. Natural size.

4. *Cladonia bacillaris* (Del.) Nyl. Lich. Lapp. Or. 179. 1866.

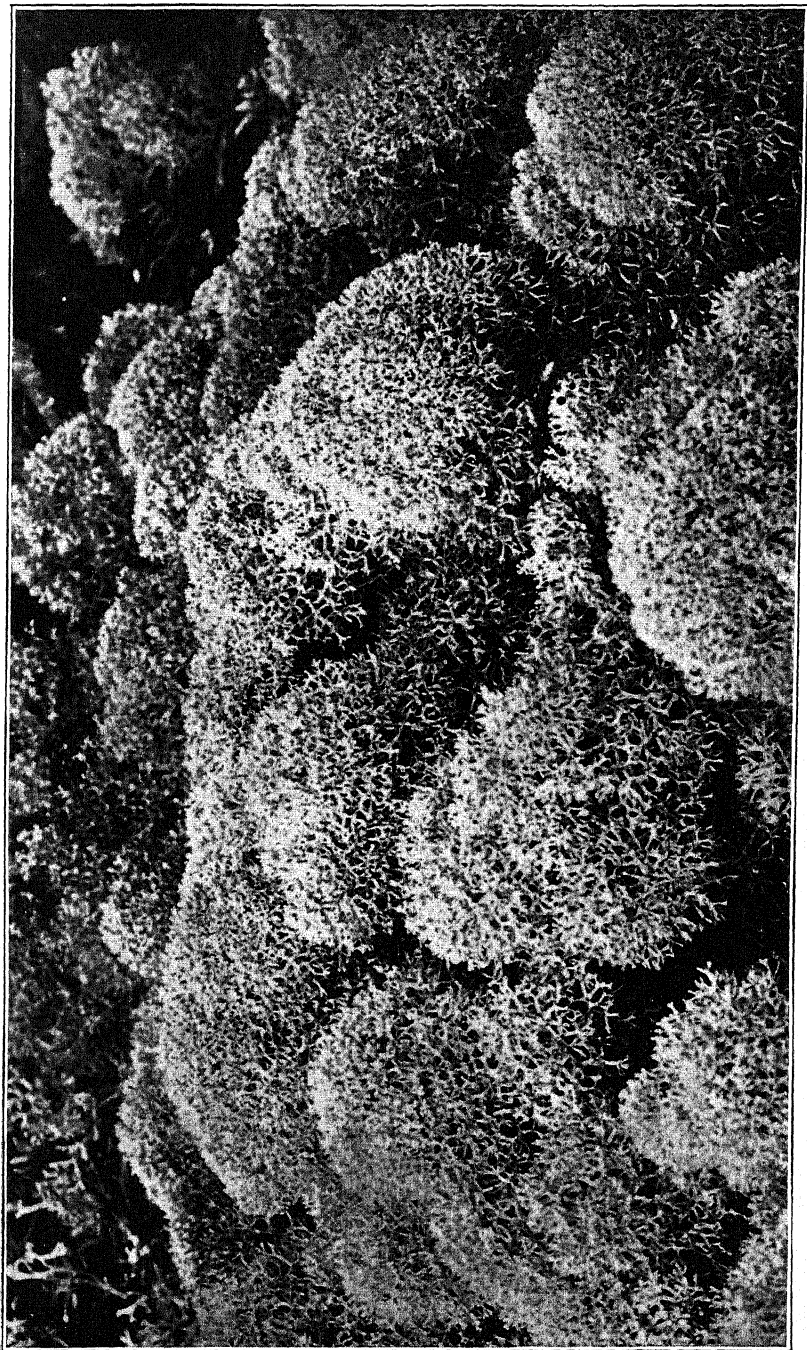
PLATE 14, A.

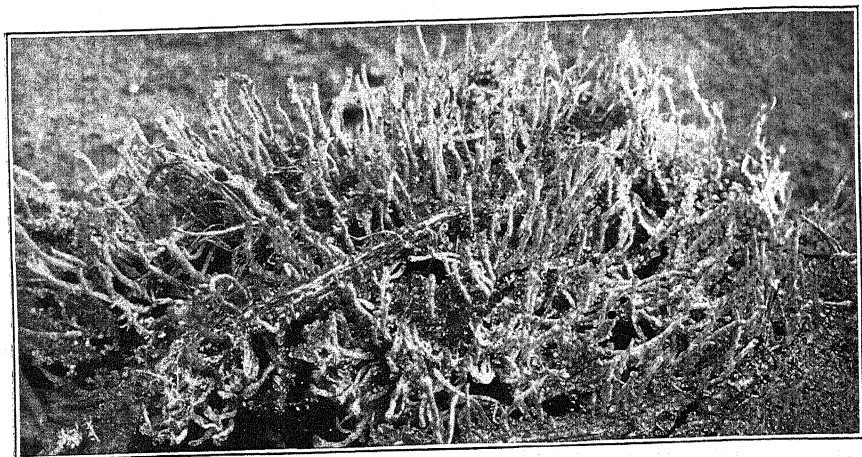
Cenomyce bacillaris Del. in DC. Bot. Gall. ed. 2. 2: 634. 1830.

Primary thallus persistent or finally dying, composed of laciniate, lobate, or crenate squamules, which are 1 to 3 mm. long, flat or somewhat involute, scattered or clustered, sea-green or varying toward whitish or olivaceous above and wholly white below or darker toward the base of the squamule, sometimes sorediate along the margin and below; podetia arising from the surface of the squamules, quite slender, subcylindrical, rarely enlarged toward the apex, 5 to 55 mm. long and 0.5 to 2 mm. in diameter, or even 4 mm. at the apex, cupless or rarely very imperfectly scyphiform, simple or rarely branched, often sterile and the apex obtuse or rarely subulate, or terminated by imperforate, clustered or solitary apothecia; erect, for the greater part or entirely sorediate, sometimes squamulose toward the base, and the squamules frequently occurring half way up or rarely even to the top, often corticate toward the base and below the apothecia, ashy, sea-green, or olivaceous, or a mixture of these colors; apothecia medium-sized, 1 to 5 mm. in diameter, solitary or clustered, immarginate or rarely thinly margined, usually convex, scarlet; hypothecium pale; hymenium reddish toward the top and paler toward the lower part; paraphyses simple or branched toward the thickened and reddish apex; asci cylindrico-clavate; spores obliquely disposed.

Usually growing on old logs or stumps, though also occurring on earth. Doubtless occurs in all portions of the State, but has been confused with the next, from which it is not easily distinguished.

CLADONIA ALPESTRIS (L.) RABENH.

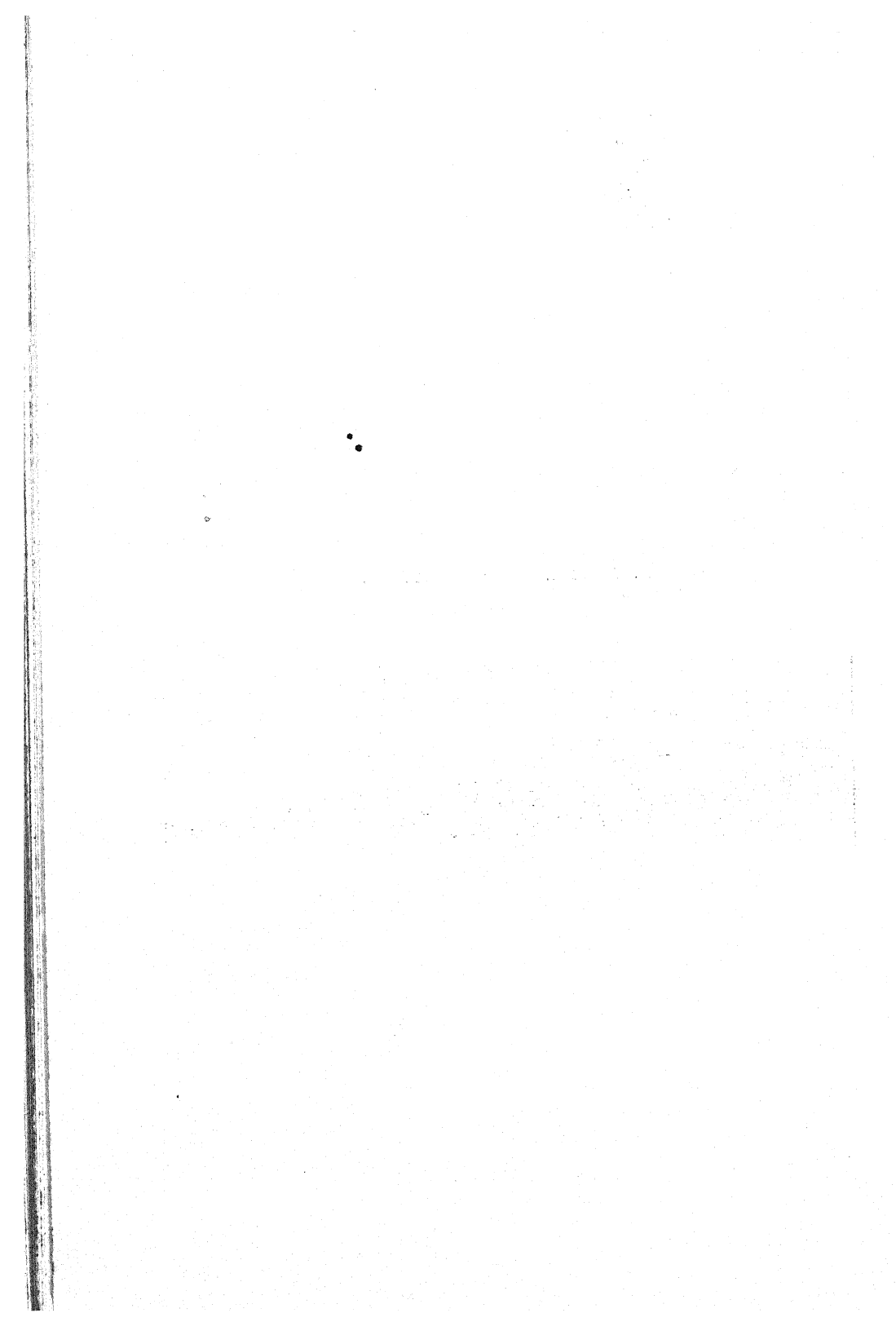




A. *CLADONIA BACILLARIS* (DEL.) NYL.



B. *CLADONIA FIMBRIATA CONIOCRAEA* (FLOERKE) WAINIO.



Little is known of its North American distribution owing to the confusion just mentioned. Known also in Europe and Africa.

EXPLANATION OF PLATE 14.—A, Plant of *Cladonia bacillaris* on humus over rocks, showing the primary thallus and the podetia. B, Plant of *C. fimbriata contocraea* on earth in pine woods, showing the cupless podetia. A natural size; B enlarged 2 diameters.

5. *Cladonia macilenta* Hoffm. Deutsch. Fl. 2: 126. 1795.

Primary thallus persistent or finally dying, composed of laciniate, lobate-laciniate, crenate, or rarely subentire, small or medium-sized squamules, these 1 to 4 mm. long and 1 to 3 mm. wide, flat or somewhat involute, scattered or clustered, sea-green, whitish sea-green, or olivaceous above, white below or darker or rarely yellow toward the base of the squamules, the margin and lower side sometimes sorediate; podetia arising from the surface of the primary thallus, short or elongated, rather slender, subcylindrical or clavate, 0.5 to 4.5 cm. long and 0.5 to 2 mm. in diameter, cupless, simple or branched, the apices obtuse or impressed, sterile or terminated by imperforate, clustered or scattered apothecia, erect, squamulose, squamulose toward the base, or rarely entirely squamulose, often corticate toward the base and below the apothecia, white or sea-green; apothecia small or more commonly middle-sized, 0.5 to 2.5 mm. in diameter, solitary or somewhat densely clustered, convex, immarginate or having a thin margin, scarlet; hypothecium pale; hymenium red above and pale yellowish below; paraphyses usually simple, more or less thickened at the pale or reddish apex; asci clavate or cylindrico-clavate; spores irregularly arranged.

The plant surely occurs in northern Minnesota, but Doctor Wainio has referred nearly all of our material, placed here in the preliminary reports, to the last preceding species. The two species are by no means clearly distinct, but the present plant is likely to be larger and to have branched podetia. The spore arrangement is not easy to make out and can not always be depended upon.

The species is known in all continents, and, according to Tuckerman's view, is widely distributed in North America. However, many of the specimens referred to here by him will doubtless have to be placed eventually with the last foregoing.

6. *Cladonia digitata* Hoffm. Deutsch. Fl. 2: 124. 1795.

Primary thallus persistent or finally dying, composed of lobed or incised, large or medium-sized squamules, which are 2 to 15 mm. long and wide, involute or somewhat flat, scattered or clustered, sea-green or rarely olivaceous above, white below or dull or yellowish toward the base, sometimes sorediate at the margins and below; podetia arising from the surface of the primary thallus, rather short but well developed, 1 to 5 cm. long, the lower part 0.5 to 4 mm. in diameter and cylindrical or often incrassate below the cups, rarely cupless; erect or decumbent, simple or repeatedly proliferous, the upper part and especially the cups sorediate or the cavity of the cups often corticate, the lower part or sometimes the whole podetium covered with a continuous cortex, without squamules or more or less squamulose, whitish or yellowish sea-green; cups medium-sized, 3 to 10 mm. in diameter, 2 to 5 mm. high, commonly abruptly dilated, regular or irregular, the margin commonly somewhat incurved, subentire, dentate, radiate or proliferate, imperforate; apothecia medium-sized, large or rarely small, 0.5 to 5 mm. in diameter, placed at the apices of the branches or rarely on the margin of the cups, single or clustered, convex and immarginate, scarlet; hypothecium pale; hymenium scarlet above, pale red below; paraphyses simple or rarely branched, somewhat enlarged toward the apex; asci cylindrico-clavate.

A rare lichen in Minnesota, thus far found only in four or five localities in the pinneries of the northern half of the State. Grows on old logs and stumps.

The plant occurs in all continents, but seems to be more common north than south of the equator and in arctic and subarctic regions. In North America confined to the northern United States and British America and mountainous regions farther south.

7. *Cladonia coccifera* (L.) Willd. Fl. Berol. Prodr. 361. 1787.

Lichen cocciferus L. Sp. Pl. 1151. 1753.

Primary thallus usually persistent, composed of irregularly or flabellately incised, crenate or lobate, small or larger squamules, which are 1 to 4 mm. long and 1 to 3 mm. wide (foreign measurements more than twice as large), flat or somewhat involute, the lower side often more or less distinctly nervose, clustered or scattered, light to reddish sea-green above and white below or yellowish toward the base, the base and the nerves yellow or red, rarely sorediate above and at the margins; podetia arising from the surface of the primary thallus, 4 to 50 mm. long and 1 to 4 mm. in diameter at the base, cup-bearing, cylindrical or turbinate, erect, corticate, sea-green, frequently yellowish or reddish-tinged, the cortex subcontinuous or areolate, in the latter case the decorticate areas between the areoles frequently white or yellowish, rarely more or less squamulose; cups gradually or abruptly dilated, sometimes becoming oblique, subentire, dentate, radiate or proliferate, 1 to 4 proliferations from a cup, themselves bearing cups or apothecia; proliferations arising from the margins of the cups or rarely from within, the lower rank 4 to 30 mm. long, the upper one or more ranks usually shorter; apothecia varying much in size, 1 to 8 mm. in diameter in ours (frequently twice as large in foreign specimens), clustered or solitary, at the dilated apices of the proliferations or sessile on the margins of the cups, convex or depressed-convex, thinly margined or more commonly immarginate, scarlet in ours; hypothecium pale; hymenium pale red above and pale below; paraphyses usually simple, somewhat enlarged at the apex; asci cylindrico-clavate.

The plant grows on earth, especially humus over rocks, and on old wood. In northern Minnesota, north and west of Duluth. Tuckerman gives the species as distributed throughout the Northern States and British America and southward in the mountains. He uses the synonym *Cladonia cornucopioides*.

The species is quite cosmopolitan in distribution, extending into temperate regions in mountains. Probably absent from Africa.

7a. *Cladonia coccifera pleurota* (Floerke) Schaer. Lich. Helv. Spic. 1: 24. 1823.

Capitularia pleurota Floerke, Ges. Nat. Freund. Mag. 2: 218. 1808.

Podetia corticate below but more or less decorticated and sorediate above; squamules usually sorediate below and along the margin; apothecia said to be sometimes marginate. The squamules seem to be somewhat smaller in this subspecies, and the apothecia frequently somewhat stipitate.

Occurs with the last, but is less common in the State, thus far only four times noted.

American and foreign distribution about the same as that of the species.

8. *Cladonia deformis* (L.) Hoffm. Deutsch. Fl. 2: 120. 1795.

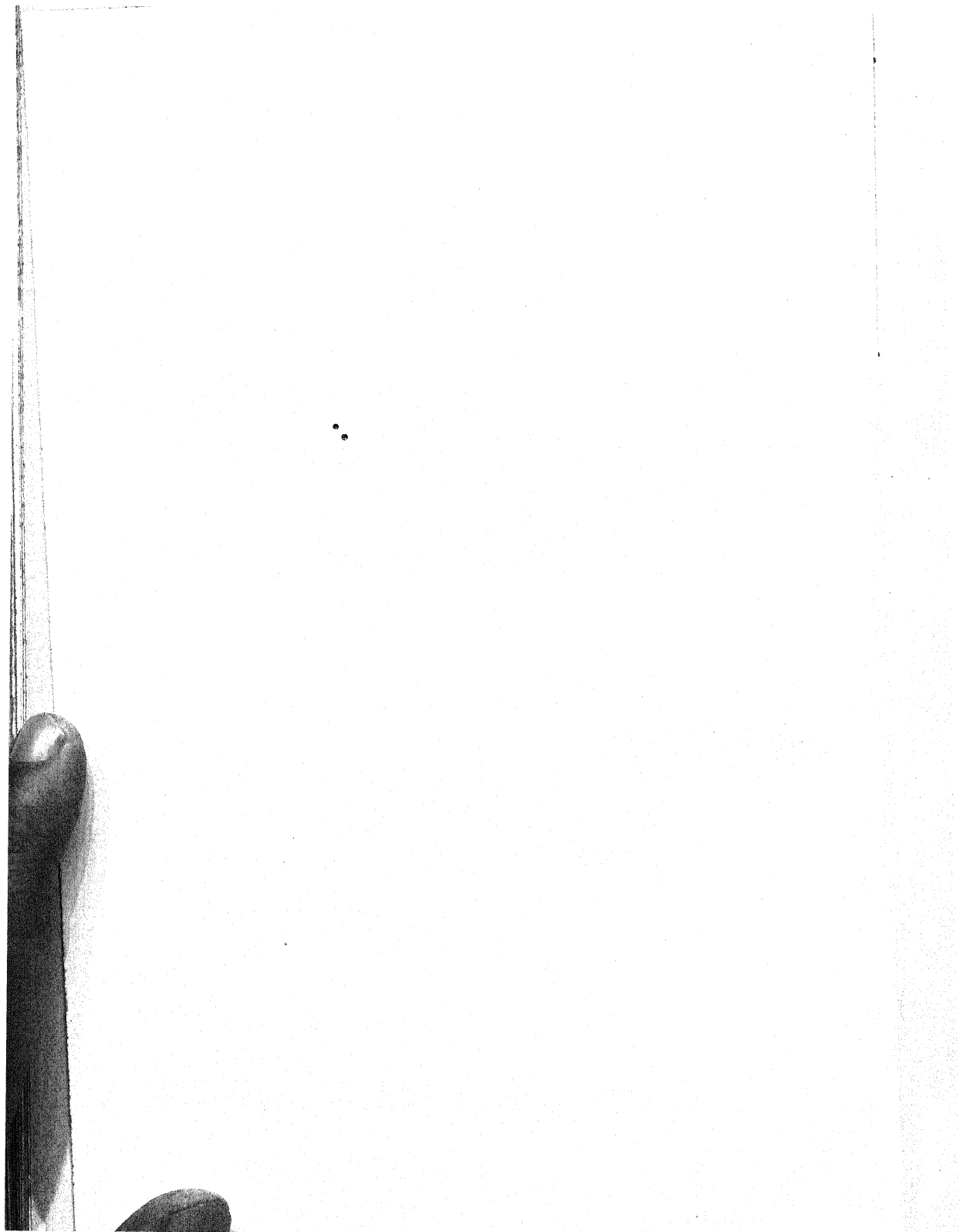
PLATE 15.

Lichen deformis L. Sp. Pl. 1152. 1753.

Primary thallus usually dying away, when present composed of incised, crenate or lobed, usually medium-sized squamules, these 2 to 7 mm. long and wide, ascending or depressed, flat or somewhat involute or convex, sometimes lacunose, scattered or clustered, sea-green, varying toward lighter or reddish, or even light red toward the base, below pale or brownish and sometimes sorediate; podetia arising from the surface of the primary thallus, 25 to 85 mm. in length, subcylindrical or rarely elongate-turbinate, scyphiform or rarely cupless, erect, partly and uniformly sorediate, the lower portion corticate, the cortex continuous and lacunose, or else rimose, the lower portion sometimes squamulose, the corticate portion yellow straw-colored to sea-green, the sorediate part sulphureous or straw-yellow; cups gradually or abruptly dilated, imperforate, medium-sized or small, 3 to 10 mm. in diameter, the margin subentire, dentate or often irregularly lacerate or proliferate, the proliferations solitary or numerous, their apices minutely scyphiform or obtuse, in 1 to 3 ranks, the lower rank long, the upper ranks and proliferations short, the cavity of the cups



CLADONIA DEFORMIS (L.) HOFFM.



usually minutely farinose; apothecia usually medium-sized, 0.5 to 5 mm. in diameter, scattered on the margins of the cups or clustered at the dilated apices of the proliferations, convex or depressed, commonly having a thin margin, scarlet; hypothecium pale; hymenium pale below and pale scarlet above; paraphyses sometimes branched, not often enlarged or colored toward the apex (?); asci cylindrico-clavate.

More or less frequent in the northern portion of the State. On earth or rarely on old wood. Ours uniformly sterile and the cups usually without proliferations, thus the plants single-ranked.

Distributed throughout the extreme northern portion of United States and through British America and farther south in the mountains. Known also in all of the grand divisions.

EXPLANATION OF PLATE 15.—Plant of *Cladonia deformis* at base of an old stump, showing the primary thallus and the podetia, some of the latter cup-bearing. Natural size.

9. *Cladonia cristatella* Tuck. Amer. Journ. Sci. 25: 428. 1858.

Primary thallus usually persistent, composed of incised or crenate, small squamules, these 2 to 3 mm. long and wide, commonly flat but sometimes involute, scattered or clustered, sea-green or straw-yellow above and whitish below, sometimes soresiate above; podetia arising from the surface of the squamules, usually of moderate length, 4 to 35 mm. long and 0.5 to 2.5 mm. wide, subcylindrical or somewhat enlarged toward the apex, without cups, simple or more or less fasciculate or digitately branched toward the apex, the branches short and obtuse, the apex or apices commonly terminated by apothecia, the axils sometimes perforate; clustered or subsolitary, erect, rarely squamulose, the cortex continuous or areolate, smooth or roughened, sea-green or straw-yellow; apothecia medium-sized or small, 0.3 to 3 mm. in diameter, solitary or clustered, convex, immarginate, scarlet; hypothecium pale or pale yellowish; hymenium pale reddish above and pale or pale yellowish below; paraphyses commonly simple, the apices only slightly thickened or colored; asci cylindrico-clavate.

Generally distributed over the State. On old wood and earth, especially common in recently burned forest regions in the northern portion of the State.

Distributed throughout the United States east of the Rocky Mountains and at least as far north in British America as Newfoundland. A North American plant.

9a. *Cladonia cristatella vestita* Tuck. Syn. N. A. Lich. 1: 255. 1882.

A form with densely squamulose podetia.

A plant collected at Tower, in the northern part of the State, was referred here by Doctor Wainio. On rocks.

Elsewhere reported from Massachusetts and New Jersey.

9b. *Cladonia cristatella paludicola* Tuck. Syn. N. A. Lich. 1: 255. 1882.

Squamules soresiate and the podetia short or wanting.

A single specimen is recorded from Mankato. On an old log. The squamules are scarcely soresiate and the determination may be regarded as doubtful.

Indefinitely reported from swamps by Tuckerman.

10. *Cladonia amaurocraea* (Floerke) Schaer. Lich. Helv. Spic. 1: 34. 1823.

Capitularia amaurocraea Floerke in Web. & Mohr, Beitr. Naturk. 2: 334. 1810.

Primary thallus rarely seen, when present composed of small crenate or digitately incised squamules, these 0.5 to 1.7 mm. long and wide, clustered or scattered, ascending or flat, sea-green above and white below; podetia formed from branches or free fragments of dying podetia, or rarely arising from the surface of the primary thallus, dying away at the base, 15 to 120 mm. long, 0.7 to 1.5 mm. in diameter, cupless and subcylindrical or sometimes cup-bearing, dichotomously or radiately or even irregularly branched, the axils closed or perforate, the branches divaricate, forming large

or small clusters, erect, ascending, or prostrate, the cortex continuous or areolate and frequently scattered, smooth or the areoles somewhat elevated, rarely somewhat squamulose toward the base, straw gold-colored or sea-green, or the decorticate portions rarely white, the basal dead portions frequently scarlet or darker, the apices straight, usually brownish, tapering and subulate, subsimple or dichotomously spinose or rarely cymosely branched, or rather rarely terminated by cups; cups commonly abruptly dilated and sometimes perforate or cribose, regular or oblique, the margin frequently spinulose and radiately lacerate and proliferous; apothecia medium-sized, 0.7 to 3.5 mm. in diameter, solitary or clustered at the apices of the podetia, thinly margined or immarginate, flat or convex, sometimes perforate, rarely lobate, brown or varying toward brick-red or lighter; hypothecium pale or pale yellowish; hymenium brownish above and pale or pale brownish below; paraphyses simple or branched toward the apex, usually enlarged and brownish; asci cylindrico-clavate.

Distributed throughout the northern portion of the State, especially to the north-east. On earth and rocks covered with humus.

Throughout the extreme northern portion of the United States, north to arctic America and also southward in the mountains. Known throughout the grand divisions.

11. *Cladonia uncialis* (L.) Hoffm. Deutsch. Fl. 2: 117. 1795.

Lichen uncialis L. Sp. Pl. 1153. 1753.

Primary thallus rarely present, composed of small crenate or incised, ascending or flat squamules, these scattered or clustered, sea-green to gold-colored above and white below, with a continuous cortex, small, 0.5 to 1 mm. long and wide; podetia formed from branches or fragments of dying podetia, or rarely arising from the margins of the squamules, dying at the base, 20 to 75 mm. long, 1 to 3 mm. in diameter, subcylindrical, usually cupless, but the apices frequently dilated and somewhat scyphiform, dichotomously, sympodially, or radiately branched, the radii 3 to 5 or more, all well developed or some shorter, the axils for the most part perforate, the cortex subcontinuous or often areolate and scattered, smooth or the areoles more or less raised, destitute of squamules, straw-colored or rarely sea-green, or the decorticate portions whitish, the apices straight, subulate or radiately or furcately spinose, rarely brown; apothecia small, 0.5 to 0.8 mm. in diameter, at the apices of short branches, solitary or clustered, immarginate or thinly margined, flat or convex, brown varying toward brick red; hypothecium usually pale; hymenium brownish above and usually pale below; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate.

Generally distributed throughout the northern portion of the State. On earth, usually over rocks.

Common throughout North America and cosmopolitan also in its foreign distribution.

11a. *Cladonia uncialis obtusata* (Ach.) Schaer. Enum. Crit. Lich. Eur. 200. 1850.

Cenomyce uncialis obtusata Ach. Lich. Univ. 559. 1810.

Thallus differing in that the apices of the branches are short and obtuse.

The axils are said to be minutely perforate, in which respect our specimen, determined by Doctor Wainio, hardly agrees.

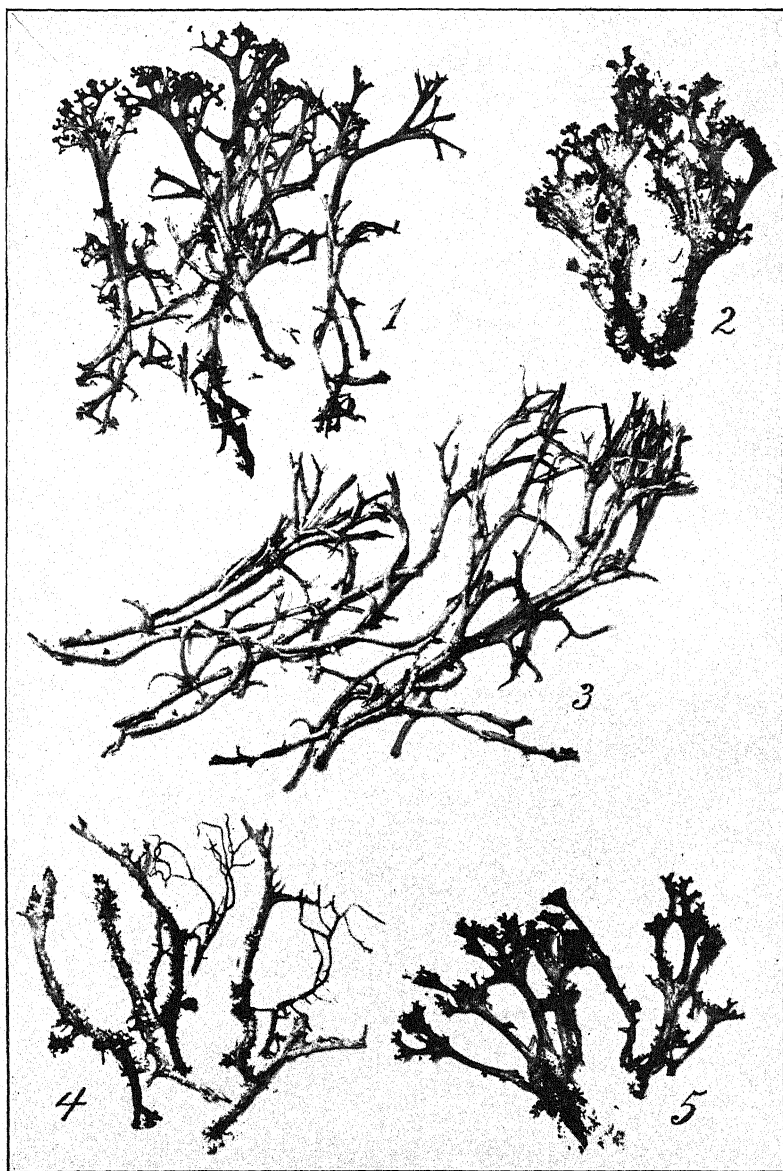
A single collection was made on Blueberry Island in Lake of the Woods. On earth.

No other record of it in North America has been found. Well known in Europe.

12. *Cladonia furcata* (Huds.) Schrad. Spic. Fl. Germ. 107. 1794.

Lichen furcatus Huds. Fl. Angl. 458. 1762.

Primary thallus usually disappearing, when present composed of medium-sized squamules, these crenately or irregularly lobed or rarely subentire, 2 to 5 mm. long and wide, ascending or flat, scattered or clustered, sea-green varying to



SUBSPECIES OF *CLADONIA FURCATA* (HUDS.) SCHRAD.

brownish or whitish above, white below, the cortical layer continuous; podetia arising from the surface of the squamules, the lower part dying away, 15 to 85 mm. long and 0.7 to 2 mm. in diameter, cylindrical or subcylindrical, very rarely scyphiform, dichotomously or frequently radiately branched, erect or rarely prostrate or decumbent, rarely somewhat sorediate, the cortex continuous or more or less dispersed, smooth or rarely subrugose, sometimes squamulose, sea-green varying toward whitish or brownish, the branches suberect, divaricate or recurved, the axils somewhat dilated and frequently perforate, the apices suberect or recurved, slender and delicate; apothecia small, 0.5 to 1.5 mm. in diameter, irregularly or cymosely disposed at the apices of the branches, immarginate, sometimes lobate or reniform, convex, rarely perforate at the center; brown varying toward brick red or lighter color; hypothecium pale; hymenium brownish above and pale below; paraphyses simple or rarely branched, frequently enlarged and brownish toward the apex; asci cylindrico-clavate.

Generally distributed over the State in one form or another. On earth, frequently over rocks, or rarely on old wood.

Generally distributed over North America. Cosmopolitan also in its foreign distribution.

12a. *Cladonia furcata scabriuscula* (Del.) Wainio, Act. Soc. Faun. Flor. Fenn. 4: 338. 1887. PLATE 16, FIGURE 4.

Cenomyce scabriuscula Del. in DC. Bot. Gall. ed. 2. 623. 1830.

Podetia more or less isidioid or sorediate, sometimes squamulose, the cortex more or less broken, partly wanting toward the top, whitish.

Frequent in the northern portion of the State and once collected as far south as Redwood Falls. Habitat as above.

Common in Europe and known also in South America and Australia. Thus far recorded elsewhere in North America only from Iowa, Canada, Newfoundland, and Massachusetts (New Bedford).

EXPLANATION OF PLATE 16.—Subspecies of *Cladonia furcata*. Fig. 1, *C. furcata racemosa*. Fig. 2, *C. furcata finkii*. Fig. 3, *C. furcata pinnata*. Fig. 4, *C. furcata scabriuscula*. Fig. 5, *C. furcata paradoxa*. Figs. 1-5, natural size.

12b. *Cladonia furcata paradoxa* (Wainio) Fink, Minn. Bot. Stud. 3: 217. 1903.

PLATE 16, FIGURE 5.

Cladonia furcata palamaea paradoxa Wainio, Act. Soc. Faun. Flor. Fenn. 4: 349. 1887.

Podetia 10 to 20 mm. long and 0.7 to 1 mm. in diameter, bearing cups 2 to 3 mm. in diameter and quite abruptly dilated, brownish or olive-brown or sea-green toward the base, there sometimes squamulose; cups irregularly proliferate, perforate, or subcribose, the proliferations cup-bearing and forming two or three ranks; apothecia seldom clustered, often perforate or lobate, brown, convex, immarginate, quite common in ours.

Frequent throughout the northern portion of the State. On old wood and earth. Not known in America outside of Minnesota. Previously known in Europe.

12c. *Cladonia furcata finkii* Wainio, Minn. Bot. Stud. 3: 217. 1903.

PLATE 16, FIGURE 2.

Podetia rather stout, 15 to 75 mm. long and 1 to 3 mm. in diameter, scyphiform and frequently 2 or 3-ranked, the cortex subcontinuous, usually more or less squamose even toward the top, whitish sea-green or slightly olivaceous, the ultimate branchlets sometimes quite similar to those of subspecies *racemosa* (pl. 16, fig. 1), but more irregular, quite commonly fruited; cups irregular and sometimes perforate, those of the upper ranks not often developed.

Wainio writes, "Scyphifera et analoga f. *paradoxae*, in quam transit, et e var. *racemosa* est evoluta, et in colore congruens."

Collected in several localities in northern Minnesota, along Rainy River and Rainy Lake; also on islands in Lake of the Woods. On earth, and on decaying wood on the ground.

Not known elsewhere.

- 12d. *Cladonia furcata pinnata* (Floerke) Wainio, Act. Soc. Faun. Flor. Fenn. 4: 332. 1887.

PLATE 16, FIGURE 3.

Cenomyce racemosa pinnata Floerke in Schleich. Cat. Pl. Helv. 47. 1821.

Podetia squamulose, the squamules incised or lobate-crenate, commonly smoothish; cortex subcontinuous or areolate, or rarely in part wanting; usually sea-green or whitish; apothecia subentire.

Collected at Gunflint and in the Misquah Hills, both in the northern portion of the State.

Wainio records the subspecies from Mexico, South Carolina, Vancouver Island, New York, and from various parts of British America. It was doubtless included in Tuckerman's conception of *C. furcata racemosa* (Hoffm.) Floerke^a, which may also occur in Minnesota. Reported from all of the grand divisions except Africa.

13. *Cladonia crispata* (Ach.) Flot. in Wendt. Therm. Warmbr. 96. 1839.

Baeomyces turbinatus crispatus Ach. Meth. Lich. 341. 1803.

Primary thallus persistent or finally dying, composed of medium-sized digitate-laciniate or crenate squamules, which are 1 to 4 mm. long and wide, ascending, flat or involute, scattered or rarely clustered and forming a compact crust, in color light or darker sea-green or even olive-brown above, below white or brownish or reddish toward the base, the cortex continuous; podetia arising from the surface of the primary thallus, the base sometimes dying away, 1 to 7.5 or possibly 10 cm. in length and 0.5 to 5 mm. in diameter, subcylindrical or irregularly turgescent, radially or sympodially branched, the branches suberect or spreading, the axils commonly somewhat dilate-open, the cortex subcontinuous or dispersed-areolate, the areoles frequently more or less raised, sometimes more or less squamulose; sea-green or variously whitish, reddish, brownish, or olivaceous, most commonly scyphiform; cups abruptly dilated and frequently perforate, borne at the apices of the branches, repeatedly proliferate at the margin; apothecia small, 0.5 to 0.7 mm. in diameter, at the apices of the short branches or at the ends of the proliferations of the cups, subsolitary or subcorymbosely aggregated, immarginate or with thin margin, flat or convex, brown or rarely brick red; hypothecium pale; hymenium pale or pale brownish below and brownish above; paraphyses commonly simple, thickened but usually pale at the apex; asci cylindrico-clavate.

Collected at several places in the northern part of the State. On earth and old wood.

Found in Massachusetts, Wisconsin, and California, and northward in British America and Alaska. Known also in South America, Europe, and Asia.

14. *Cladonia subsquamosa* (Nyl.) Wainio, Acta Soc. Faun. Flor. Fenn. 4: 445. 1887.

Cladonia delicata subsquamosa Nyl. Ann. Mag. Nat. Hist. III. 18: 407. 1866.

Primary thallus composed of middle-sized squamules, these commonly disappearing sooner or later; podetia arising from the surface of the squamules, 12 to 35 mm. long in ours and becoming twice as long in foreign plants, subcylindrical or tubæform, sometimes scyphiform, irregularly branched or rarely simple, the axils sometimes perforate, the apices scyphiform, obtuse, perforate or rarely subulate, erect, the cortex verrucose or areolate or almost wholly wanting; sometimes squamulose toward the base, and squamulose-scaly higher up, whitish sea-green or varying toward brownish, the base sometimes dying and becoming dark-colored; cups when present perforate, and the margin becoming repeatedly proliferate; apothecia commonly small,

^a Clad. Comm. 152. 1828.

0.5 to 0.7 mm. in diameter, subsolitary or more or less aggregated at the apices of the branches, flat and thinly margined or becoming convex and immarginate, brown; hypothecium pale; hymenium pale below and brownish above; paraphyses with thickened apices; asci clavate.

Our plant is sterile, and the apothecial characters are taken from Wainio.

A single collection from Emo was placed here by Doctor Wainio. On earth over rocks.

Previously known in North America only from Vancouver Island, Puget Sound, and Alaska. A rare plant, Wainio citing a single station each for Europe, South America, and Australia.

15. *Cladonia squamosa* (Scop.) Hoffm. Deutsch. Fl. 2: 125. 1795.

Lichen squamosus Scop. Fl. Carn. ed. 2. 2: 368. 1772.

Primary thallus commonly persistent, composed of middle-sized or rarely large, crenate, irregularly subdigitate or subpinnate-lacinate squamules, these 1.5 to 7 mm. long and 1 to 5 mm. wide, ascending, flat or involute, scattered or clustered and rarely cespitose so as to form a compact crust, sea-green varying toward ashy or brown above, below white, the cortex continuous; podetia arising from the surface of the primary thallus, rarely dying at the base, 10 to 85 mm. long and 2 to 5 mm. in diameter, subcylindrical or rarely trumpet-shaped, irregularly turgescient, clustered, erect, ascending, decumbent or irregularly flexuous, rarely simple or commonly more or less irregularly or radiately branched, the branches erect or spreading, the axils frequently open, the cortex areolate, or subcontinuous toward the base, the areoles sometimes scattered or entirely disappearing above, the podetia sorediate above, the corticate portions commonly squamulose with frequently lacinate squamules, ashy, sea-green, olivaceous, or brown, or variegated with these colors, commonly scyphiform; cups abruptly dilated, medium-sized or small, usually perforate, the margin commonly repeatedly proliferate; apothecia small, 0.5 to 0.7 mm. in diameter, on the margin of the cups or at the ends of branches or proliferations, subsolitary or clustered, thinly margined or immarginate, flat or becoming convex, brown or rarely pale brown or possibly brick-red; hypothecium pale; hymenium pale or pale brownish below and commonly brownish above; paraphyses usually simple, sometimes thickened and brownish toward the apex; asci clavate or cylindrico-clavate.

Generally distributed over the State. On old wood and earth.

The plant is widely distributed in North America and is also quite cosmopolitan in its foreign distribution.

15a. *Cladonia squamosa multibrachiata* (Floerke) Wainio, Act. Soc. Faun. Flor. Fenn. 4: 437. 1887.

Cladonia squamosa asperella multibrachiata Floerke, Clad. Comm. 133. 1828.

Podetia scyphiform and almost destitute of squamules.

Ours, determined by Doctor Wainio, is a small plant, 10 to 25 mm. long and 1 to 2.5 mm. in diameter, with cups irregular and proliferate.

The plant determined by Doctor Wainio is from Rainy Lake City. Others from Gunflint and Snowbank Lake seem to be the same.

Not known elsewhere in North America. Otherwise confined to Europe.

15b. *Cladonia squamosa phyllocoma* (Rabenh.) Wainio, Act. Soc. Faun. Flor. Fenn. 4: 441. 1887.

Cladonia squamosa macrophylla phyllocoma Rabenh. Clad. Eur. Exsicc. pl. 26. no. 20. 1860.

Podetia scyphiform, corticate, more or less squamulose with rather large squamules.

A single collection from Emo on the international boundary has been placed here by Doctor Wainio. A European form not known elsewhere in North America.

16. *Cladonia caespiticia* (Pers.) Floerke, Clad. Comm. 8. 1828.

Baeomyces caespiticus Pers. Ann. Bot. Usteri 7: 155. 1794.

Primary thallus persistent and composed of subdigitately lacinate, incised or crenate, ascending, flat or rarely involute squamules, these middle-sized, 2 to 10 mm. long and 1.5 to 8 mm. in width, commonly clustered and thus forming larger or smaller patches, sea-green varying toward whitish or olivaceous, the cortex continuous, frequently sorediate below, the color there white; podetia arising from the surface of the primary thallus, abortive or 1 to 5 mm. long and 0.4 to 1.5 mm. in diameter, subcylindrical or clavate, cupless, simple or rarely branched, the apices obtuse and always bearing apothecia; sometimes open at the apex, scattered, erect, decorticate, rarely squamulose, usually ashy in color; apothecia medium-sized or larger, 0.75 to 3 mm. in diameter, borne at the apices of podetia or rarely sessile, solitary or slightly clustered, thinly margined or immarginate, flat or convex, brown or reddish brown; hypothecium pale; hymenium pale below and pale or brownish above; paraphyses simple, the apices enlarged and pale or brownish; asci cylindrico-clavate.

Reported from widely separate portions of the State, but some of the material is doubtful. Certainly distributed widely in northern Minnesota, and doubtless to be found in all portions of the State. On rocks and old wood.

Distributed throughout the United States east of the Rocky Mountains and northward into British America. Also common in Europe, but scarcely extending into extreme arctic regions in either hemisphere.

17. *Cladonia delicata* (Ach.) Floerke, Clad. Comm. 7. 1828.

Lichen delicatus Ach. Lich. Suec. 199. 1798.

Primary thallus commonly persistent, composed of small lacinate, erose, or crenate squamules, these 1 to 2.5 mm. long and wide, ascending, flat or involute, commonly clustered and frequently forming a crust, ashy, sea-green or olivaceous above, below white and usually more or less sorediate, the cortex continuous above; podetia arising from the surface of the primary thallus, 3 to 10 mm. long and 0.5 to 1 mm. in diameter, cupless, subcylindrical, clavate or irregularly turgescent, usually simple or slightly branched at the apex, rarely quite freely branched lower down, the axils, the apices, and the sides sometimes more or less fissured; scattered or clustered, erect, commonly more or less sorediate and decorticate, and usually sorediate-furfuraceous, the apices usually apothecia-bearing and obtuse, but rarely sterile and subulate; apothecia small, 0.3 to 1.5 mm. in diameter, borne in clusters or solitary at the apices of the podetia or branches, thinly margined or immarginate, flat or convex, brown or rarely reddish brown; hypothecium pale or pale brownish; hymenium brownish and darker above; paraphyses simple or branched, the apices frequently thickened and pale brownish; asci clavate or cylindrico-clavate.

Collected at Taylors Falls, Beaver Bay, and Warroad. Thus widely distributed, but probably rare in the State. On old wood.

Distributed throughout the eastern half of the United States and northward into British America. Known in all the grand divisions.

18. *Cladonia cenotea* (Ach.) Schaer. Lich. Helv. Spic. 1: 35. 1823.

Baeomyces cenoteus Ach. Meth. Lich. 345. pl. 7. f. 7. 1803.

Primary thallus usually persistent, composed of middle-sized or small, irregularly divided, incised or subentire squamules, these 1 to 3 mm. long and wide, ascending, flat or involute, scattered or clustered, ashy, sea-green, brownish, or olivaceous above, the cortex continuous, beneath white and sometimes more or less sorediate; podetia arising from the surface of the primary thallus, 5 to 60 mm. long and 0.5 to 5 mm. in diameter (foreign specimens reaching 10 cm. long), subcylindrical, irregularly turgescent or trumpet-shaped, commonly erect, wholly decorticate and finely sorediate, or corticate toward the base, there also sometimes more or less squamulose, ashy, sea-green or

brownish or variegated with these colors, the apices scyphiiform or cupless, in the latter case attenuate and perforate, rather rarely branched, the sides frequently perforate also, commonly more or less clustered; cups 2.5 to 8 mm. in diameter, perforate, commonly proliferate, the podetia thus becoming 2 or several-ranked; apothecia small, 0.5 to 1.5 mm. in diameter, borne on the margins of the cups or at the margins of branches or proliferations, subsolitary or more or less clustered, thinly margined or immarginate, flat or convex, brown or flesh-colored; hypothecium pale; hymenium usually pale brownish below and somewhat deeper brownish above; paraphyses simple or compound, the apex thickened and pale or brownish; asci clavate or cylindrico-clavate.

Distributed throughout the northern portion of the State. On old logs and on earth.

Found in the New England States; widely distributed throughout British America and in Alaska. Also reported from the Cascade Mountains. Known also in Europe, Asia, and Australia.

19. *Cladonia turgida* Hoffm. Deutsch. Fl. 2: 124. 1795.

Primary thallus commonly persistent, composed of large foliose laciniate or irregularly or subdichotomously lobed squamules, these 5 to 25 mm. long and 2 to 8 mm. wide, ascending or nearly erect, flat, convex and canaliculately revolute or even concave and involute, often cespitose in small or medium-sized clusters, ashy to sea-green above and white beneath, the cortex continuous; podetia arising from the surface of the primary thallus, one or more from a single squamule, the base sometimes dying away, 2 to 7 cm. long and 2 to 3 mm. in diameter, turbinate or subcylindrical and frequently turgescerent, often more or less branched, the branches suberect, the axils frequently more or less open, scattered or cespitosely clustered, erect or ascending, areolate or with continuous cortex, sometimes more or less clothed with usually large squamules, light sea-green or the decorticate portions between the areoles white, the apices cupless, obtuse and bearing short branches, or imperfectly scyphiiform, frequently olive-brown; cups somewhat dilate, shallow, perforate or cribose, radiately proliferate from the margin; apothecia small or medium-sized, 0.5 to 2 mm. in diameter, borne at the apices of the branches or proliferations, subcymosely or radiately arranged and frequently short-stipitate, thinly margined or convex and immarginate, brown or rarely reddish brown, often perforate; hypothecium pale; hymenium pale or pale brownish below and more brownish above; paraphyses simple or rarely branched, the apices usually thickened and brownish; asci cylindrical or cylindrico-clavate.

For the most part confined to the northern portion of the State, but once collected as far south as New Ulm. On earth, especially over shaded rocks.

Throughout the extreme northern portion of the United States and British America. Common in the colder portions of Europe.

20. *Cladonia mitrula* Tuck. in Darl. Fl. Cestr. ed. 3. 444. 1853.

Primary thallus commonly persistent, composed of irregularly or subdigitately laciniate or crenate, flattish, ascending or suberect, clustered, small or middle-sized squamules; these 1.5 to 4 mm. in length and nearly or quite as wide, ashy to sea-green above and whitish below; podetia arising from the surface of the primary thallus, 0.5 to 15 mm. long and 0.4 to 1.6 mm. in diameter, cylindrical and cupless, always terminated by apothecia, simple or branched toward the apex, the branches suberect or spreading, sometimes fissured longitudinally, the axils sometimes open, clustered or subsolitary, erect, the cortex continuous or composed of contiguous or subcontiguous areoles, or the surface rarely in part decorticate and somewhat sorediate, sometimes more or less squamulose, ashy to sea-green or the decorticate portions whitish; apothecia small or middle-sized, 1 to 2 mm. in diameter, solitary or clustered, sometimes perforate, flat and marginate or convex and immarginate, brown

varying toward paler or reddish brown; hypothecium pale or brownish; hymenium pale or brownish below and brownish above; paraphyses usually simple, commonly thickened and brownish toward the apex; asci clavate.

Frequent in the southern half of the State, but replaced northward by *Cladonia cariosa*. On earth.

Common throughout the United States, especially so toward the south. Not common in British America, but reported as far north as Alaska. Also known in South America.

21. *Cladonia cariosa* (Ach.) Spreng. Syst. Veg. 4: 272. 1827.

Lichen cariosus Ach. Lich. Suec. 198. 1798.

Primary thallus persistent or replaced by new squamules, composed of irregularly laciniate, incised or crenate, concave, flat, involute or revolute, ascending or suberect, clustered or rarely scattered squamules, these small or medium-sized, 1 to 6 mm. long and 1 to 5 mm. wide, pale sea-green above varying toward olivaceous, whitish below or brownish toward the base, the cortex continuous or more or less sorediate above and along the margin; podetia arising from the surface or margin of the squamules, 5 to 30 mm. long and 1 to 2 mm. in diameter, subcylindrical or thickened toward the top, cupless and always terminated by apothecia, usually freely branching, sometimes even from the base, the branches spreading or more usually suberect, the sides commonly more or less fissured or grooved; clustered or subsolitary, usually suberect; cortex subcontinuous or areolate, the areoles frequently scattered, rarely squamulose, more commonly so toward the base, pale sea-green or whitish, the decorticate portions of the surface between the areoles white; apothecia usually medium-sized, 1 to 2 or even 4 mm. in diameter, clustered-conglomerate, frequently perforate, borne at the apices of the podetia, flat or becoming convex and immarginate, lighter or darker brown or possibly rarely reddish brown; hypothecium pale; hymenium brownish above and pale or brownish below; paraphyses simple or rarely branched, thickened and brownish toward the apex; asci clavate or cylindrico-clavate.

Widely distributed in the State, but more common toward the north. On earth or rarely on old wood.

Distributed throughout North America. Found in all the grand divisions.

22. *Cladonia decorticata* (Floerke) Spreng. Syst. Veg. 4: 271. 1827.

Capitularia decorticata Floerke in Weber & Mohr, Beitr. Naturk. 2: 297. 1810.

Primary thallus finally disappearing and usually more or less replaced by new squamules, these laciniate or crenate, somewhat concave or involute, scattered or clustered, usually small, 1 to 4 mm. long and 1 to 2 mm. wide, light sea-green, above varying toward olivaceous, beneath whitish, or brownish toward the base; podetia arising from the surface of the primary thallus, 1 to 10 cm. long and 0.75 to 2 mm. in diameter, cylindrical, cupless, simple or more or less dichotomously or irregularly branched, the branches commonly erect or spreading, the fertile apices often dilated, the sterile ones obtuse or subulate, the sides sometimes fissured; clustered or subsolitary, erect or rarely ascending or even decumbent, variously sorediate, areolate, and squamulose, the latter especially toward the base, decorticate between the areoles or squamules toward the base, pale sea-green or brownish, the decorticate portions white; apothecia middle-sized, 0.75 to 4.5 mm. in diameter, confluent or conglomerate, borne at the apices of the podetia or branches, concave, flat or convex, thinly margined or finally immarginate, usually brown; hypothecium pale; hymenium pale or pale brownish below and brownish above; paraphyses usually simple, commonly thickened and brownish toward the apex; asci clavate or cylindrico-clavate.

Collected in several widely separate localities in the State, but hardly common. On earth and old wood.

Known in the White Mountains of New Hampshire and widely distributed in British America and Alaska. Found also in Europe and Asia.

23. *Cladonia gracilis* (L.) Willd. Fl. Berol. Prodr. 363. 1787.*Lichen gracilis* L. Sp. Pl. 1152. 1753.

Primary thallus usually persistent, composed of irregularly lacinate or crenate, somewhat flat, involute or convolute, ascending, clustered or scattered squamules, these somewhat incrassate, middle-sized, 2 to 5 mm. long and nearly as wide, sea-green varying to olivaceous above, white below or brownish toward the base; podetia arising from the surface of the primary thallus, 10 to 75 mm. long and 0.3 to 5.5 mm. in diameter, cylindrical and cupless or trumpet-shaped and scyphiform, commonly in larger or smaller clusters, erect or ascending, the cortex subcontinuous or composed of contiguous or scattered areoles, rarely squamulose toward the base, the decorticate portions between the areoles sometimes granulose-sorediate; variously sea-green, ashy, olivaceous, or even reddish brown, the decorticate portions white, sometimes dying below and the dead portion becoming dark-colored, simple or more or less branched, the sides sometimes more or less rimose or perforate; cups 0.75 to 6 mm. in diameter, abruptly or gradually dilated, regular or subregular, shallow or deep, the margin dentate or proliferate, rarely proliferate from the center, the ranks from 1 to 5, the lowest 10 to 70 mm. long, when four or five, the whole podetium sometimes longer than the measurements given above; apothecia medium-sized, 1 to 4.5 mm. in diameter, usually lobate-conglomerate and sometimes perforate, commonly borne on short pedicels, these frequently arising singly or in clusters from the margins of the cups, thinly margined or more commonly convex and immarginate, pale or darker brown; hypothecium pale; hymenium pale below and brownish above; paraphyses rarely branched, thickened and brownish toward the apex; asci cylindrico-clavate.

Generally distributed over the State. On earth or rarely on rotten wood.

Widely distributed in North America and cosmopolitan elsewhere.

23a. *Cladonia gracilis dilacerata* Floerke, Clad. Comm. 37. 1828.

Differing from the last in that the cups are usually more irregular and the podetia are squamulose.

Cladonia gracilis anthocephala Floerke^a was recognized by Doctor Wainio among our material, but scarcely differs from the above.

The forms referred to subspecies *dilacerata* are confined to the northern portion of the State. On earth or rotten wood.

Little is known of its North American distribution. Credited to Greenland by Wainio. *Cladonia gracilis hybrida* Tuck.^b may be this in part, though Tuckerman's plant is no doubt for most part the last subspecies above. Well known in Europe.

24. *Cladonia degenerans* (Floerke) Spreng. Syst. Veg. 4: 273. 1827.*Basomyces degenerans* Floerke, Ges. Naturf. Freund. Mag. 1: 288. 1807.

Primary thallus more or less evanescent, composed of usually medium-sized, irregularly laciniately lobed, flat or somewhat involute or convolute, ascending, scattered, or clustered squamules, these 2 to 12 mm. long and 1.5 to 10 mm. wide, sea-green varying toward olivaceous above and white below or darkening toward the base; podetia arising from the surface of the primary thallus, 10 to 55 mm. long and 0.5 to 3.5 mm. in diameter, more or less irregularly cylindrical or turbinate, erect or ascending, the cortex areolate, with commonly elevated and frequently scattered areoles, the portions between the areoles subtomentose, sometimes squamulose; sea-green varying toward ashy or olivaceous, the decorticate portions white, the sides rarely more or less grooved; occurring in larger or smaller clusters, frequently scyphiform-proliferate; cups 1.5 to 8.5 mm. in diameter, abruptly or gradually dilated, usually more or less irregular, urceolate or shallow, commonly dentate or proliferate, the proliferations arising either from the margin or from the center of the cup and either solitary or radiately arranged, the ranks 1 to 5 in number, the lowest 3 to 20

^a Clad. Comm. 37. 1828.^b Syn. Lich. N. E. 49. 1848.

mm. long, the sterile apices scyphiform, cornute, or rarely subulate; apothecia small to medium-sized, 0.5 to 2.5 mm. in diameter, regular or finally lobate and perforate, solitary or variously clustered at the apices of podetia or proliferations, convex or flat, immarginate, brown varying toward pale or reddish brown; hypothecium pale; hymenium pale below and pale brownish above; paraphyses simple or branched, frequently thickened and brownish toward the apex; asci cylindrico-clavate.

Ours sterile and the spore and apothecial characters taken from European material. Collected several times along the international boundary and also at Tower and Bemidji. On earth, frequently over rocks.

Appears to be widely distributed in North America, though much of the material is quite uncertain. Known in all the grand divisions.

24a. *Cladonia degenerans euphorea* (Ach.) Nyl. Syn. Lich. 1: 200. 1858.

Cenomyce gonorega euphorea Ach. Syn. Lich. 289. 1814.

Podetia without squamules or the lower portion sparsely squamulose, the sterile cups regular and the fertile ones subregular, sometimes proliferate.

In ours, determined by Doctor Wainio from Kettle Falls, the sides of the podetia are frequently perforate. The plant is sterile, and the determination is one well-nigh impossible to make without authentic specimens.

Collected along the international boundary from Harding to Rainy Lake City. On earth, over rocks.

Not known elsewhere in America. Well known in Europe.

24b. *Cladonia degenerans cladomorpha* (Ach.) Wainio, Act. Soc. Faun. Flor. Fenn. 10: 141. 1894.

Baeomyces alicornis cladomorpha Ach. Syn. Lich. 350. 1814.

Podetia without squamules or sparsely squamulose toward the base, scyphiform, the cups irregular with lacerate and sometimes proliferate margins.

A single collection was made at Emo on the international boundary. On earth, over rocks.

Not known elsewhere in America. Well known in Europe.

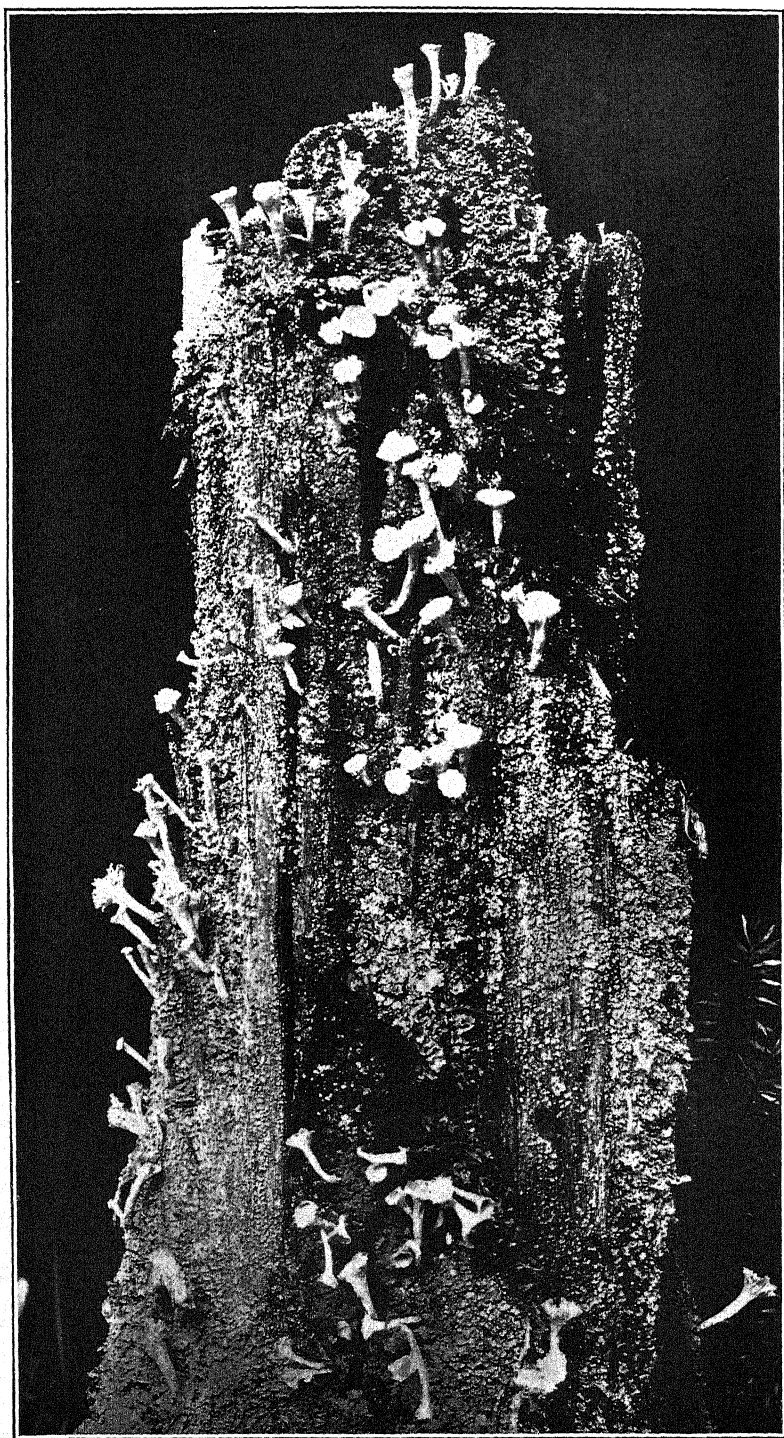
25. *Cladonia verticillata* Hoffm. Deutsch. Fl. 2: 122. 1795.

Primary thallus commonly persistent, composed of irregularly subcuneate or crenately lobed, or even incised-lobate, flat or somewhat involute, ascending, clustered or scattered, medium-sized or larger squamules, these 1.5 to 7.5 mm. long and wide, sea-green above or more commonly varying toward ashy, olivaceous, or even brownish, below white or darkening toward the base; podetia arising from the squamules, 3 to 55 mm. long and 0.5 to 3.5 mm. in diameter, tubæform or more rarely turbinate, subsolitary or clustered into small patches, erect or rarely ascending, the cortex subcontinuous, grooved or areolate with commonly closely contiguous areoles, destitute of squamules or rarely more or less squamulose at the base of the podetia or at the margins of the cups, sea-green varying toward ashy, yellowish, brownish, or olivaceous, or variegated with these colors, the narrow decorticate portions between the areoles white or rarely reddish, scyphiform; cups medium-sized or large, 2.5 to 9 mm. in diameter, usually abruptly dilated, shallow, the margin subentire or dentate, commonly proliferate from the closed cavity of the cup, the proliferations 1 to several, and the ranks commonly 2 to 5, the lowest one about 20 mm. long; apothecia small or medium-sized, 0.5 to 2.5 mm. in diameter, rounded or irregular and perforate, sessile on the margin of the cups or shortly pedicellate, flat and thinly margined or becoming convex and immarginate, paler or darker brown; hypothecium pale; hymenium commonly pale below and brownish above; paraphyses simple or rarely branched, commonly thickened and brownish toward the apex; asci cylindrico-clavate.

Generally distributed over the State. On earth, or on rocks covered with humus.

The plant is generally distributed over North America. Known also in all of the grand divisions, and one of the most cosmopolitan of lichens.





CLADONIA PYXIDATA CHLOROPHAEA (SPRENG.) FLOERKE.

25a. *Cladonia verticillata cervicornis* (Ach.) Flot. Linnaea 22: 380. 1849.*Lichen cervicornis* Ach. Lich. Suec. 184. 1798.

Primary thallus persistent, composed of rather large or medium-sized, usually densely clustered, lacinate squamules, these about 5 to 12 mm. long; podetia rather short and slender for the species, 2 to 20 mm. long and 0.3 to 1 mm. in diameter, simple or proliferous from the central portions of the cups, or rarely from the margins or even from the sides of the podetia below the cups, the ranks 1 to 3, the upper ranks often without cups and branched irregularly, without squamules or squamose about the margins of the cups.

Once collected in the State, at Koochiching. On earth.

Elsewhere in North America from New England, Mississippi, and arctic America. Known also in all the grand divisions.

26. *Cladonia pyxidata* (L.) Hoffm. Deutsch. Fl. 2: 121. 1795.*Lichen pyxidatus* L. Sp. Pl. 1151. 1753.

Primary thallus commonly persistent, composed of irregularly or digitately incised or lobate, flat, concave or rarely convex, commonly ascending, clustered or scattered squamules, these 2 to 8 mm. long and 1.5 to 6 mm. wide, sea-green above or varying toward whitish or olivaceous, commonly lighter and sorediate below; podetia arising from the surface of the primary thallus, 3.5 to 30 mm. long and 3 to 4.5 mm. in diameter, turbinate or tubiform, erect, the cortex areolate or verrucose or subcontinuous toward the base, rarely more or less squamulose, sea-green varying toward ashy or olivaceous, the decorticate portion white or ashy-brown, frequently closely clustered, scyphiform; cups 1 to 7 mm. in diameter, regular or irregular, on well-developed podetia or the dilation beginning just above the primary thallus, the cavity non-perforate, sorediate or corticate, entire, dentate or proliferate from the margin, the proliferations 1 or more, the ranks 1 to 3; apothecia scarcely common, medium-sized, 1 to 4 mm. in diameter, solitary or conglomerate, regular or irregular, sessile on the margins of the cups or on longer or shorter pedicels, flat and thinly margined or more commonly convex and immarginate, commonly brown, and ours all of some shade of brown; hypothecium pale or pale brownish; hymenium pale or pale brownish below and brownish above; paraphyses simple or rarely branched, commonly thickened and brownish toward the apex; asci clavate.

Generally distributed over the State. On earth or rotten wood.

Widely distributed in North America. Cosmopolitan in its foreign distribution.

26a. *Cladonia pyxidata chlorophaea* (Spreng.) Floerke, Clad. Comm. 70. 1828.

PLATE 17.

Cladonia chlorophaea Spreng. Syst. Veg. 4: 273. 1827.

Podetia more or less decorticate and sorediate toward the top.

Thus far found only in the northern portion of the State, but no doubt generally distributed, though not so common as the species.

Reported elsewhere in North America only from Massachusetts, Pennsylvania, and Ohio, and northward to Great Bear Lake, but doubtless generally distributed. Known in all the grand divisions.

EXPLANATION OF PLATE 17.—Plant on an old stump, showing primary thallus and the cup-bearing podetia. Natural size.

26b. *Cladonia pyxidata pocillum* (Ach.) Flot. Linnaea 17: 19. 1843.*Baeomyces pocillum* Ach. Meth. Lich. 336. pl. 8. f. 6. 1803.

Primary thallus of rather large and thick, round-lobed or somewhat incised, closely adnate or slightly ascending squamules, these more or less imbricated and closely packed into a commonly olivaceous or brownish crust; podetia simple and sterile, partly decorticate above but not sorediate.

A single collection was made at Grand Marais. On humus over rocks along Lake Superior. Not previously reported from Minnesota.

An arctic and subarctic form widely distributed in British America, and found in Alaska. Known also in Europe, Asia, and Africa.

27. *Cladonia fimbriata* (L.) Hoffm. Deutsch. Fl. 2: 122. 1795.

Lichen fimbriatus L. Sp. Pl. 1152. 1753.

Primary thallus commonly persistent, composed of digitate or irregularly incised or lobate, flat or concave, frequently involute or convolute, ascending, clustered or scattered medium-sized squamules, these 2 to 9 mm. long and wide; sea-green above varying toward olivaceous or whitish, below whitish or darkening toward the base, sometimes sorediate-granulose below and along the edges; podetia arising from the surface of the squamules, 4 to 80 mm. long and 0.5 to 3.5 mm. in diameter, cylindrical to tubæform or rarely turbinate, commonly clustered into larger or smaller groups, erect, or rarely ascending or irregularly curved, commonly decorticate and more or less sorediate, or areolate or verrucose-corticate toward the base or the corticate basal portion even subcontinuous, destitute of squamules or more or less squamulose, especially toward the base, sea-green varying toward whitish or brownish, the decorticate portions commonly whitish, sometimes scyphiform, or the apices frequently cornute or subulate; cups well developed or abortive, abruptly or gradually dilated, regular or irregular, the cavity commonly deep, the margin entire, dentate, or proliferate, the proliferations 1 to several and the ranks 1 to 3; apothecia commonly medium-sized, 0.8 to 2 mm. in diameter, solitary and rounded or irregularly conglomerate; sessile or pedicellate on the margins of the cups or at the cornute or subulate apices, flat and thinly margined or more commonly becoming convex and immarginate, brown or reddish brown; hypothecium pale; hymenium pale or pale brownish below and brownish above; paraphyses rarely branched, commonly thickened and brownish toward the apex; asci clavate or cylindrico-clavate.

Generally distributed over the State, in some of the several following forms. On earth and old wood.

Generally distributed over North America, though the subspecies are not, as a rule, well enough known to permit any definite statement to be made concerning their American distribution. Cosmopolitan also in its foreign distribution.

The subspecies given below are connected by various intermediate forms and altogether form the most confusing assemblage of lichens known to our flora. The best descriptions can do little more than lessen the difficulties of determination.

27a. *Cladonia fimbriata simplex* (Weiss) Wainio, Act. Soc. Faun. Flor. Fenn. 10: 256. 1894.

Lichen pyxidatus simplex Weiss, Pl. Crypt. Gott. 84. 1770.

Podetia scarcely exceeding 3 to 30 mm. in length, scyphiform, the cups well developed, 2 to 7 mm. in diameter, regular or becoming suboblique, with entire or dentate margins, the podetium erect and straight; apothecia sessile or pedicellate on the margins of the cups. Doctor Wainio further divides the variety into two subvarieties.^a

Thus far found only in the northern portion of the State.

The plant is widely distributed in North America. Known also in all the grand divisions.

27b. *Cladonia fimbriata prolifera* (Retz.) Mass. Sched. Crit. Lich. Exsicc. no. 155. 1855.

Lichen fimbriatus prolifer Retz. Fl. Scand. Prodr. 232. 1779.

Podetia 20 to 70 mm. long, scyphiform, repeatedly proliferate from well-developed cups, commonly straight and erect, wholly decorticate and for most part sorediate, or having a minutely areolate or verrucose cortex below, sometimes squamulose, especially toward the base; cups 2 to 10 mm. in diameter, commonly somewhat

^a See Wainio, Act. Soc. Faun. Flor. Fenn. 10: 258. 1894.

abruptly dilated, regular or rarely oblique; proliferations one or more from each cup, the ranks 2 to 3 or rarely more, the upper ranks usually quite as long as the lower and scyphiform, but the terminal cups commonly narrowed; apothecia usually borne on the cups of the higher ranks.

The plant referred to this species was collected at Warroad. On earth in a swamp.

Reported from Vancouver Island and Newfoundland; otherwise unknown in North America outside of Minnesota. Known in Europe, Asia, and South America.

27c. *Cladonia fimbriata cornutoradiata* Coem. Bull. Acad. Roy. Belg. 19: 40. 1865.

Podetia elongated, sometimes bearing narrowed or abortive cups, simple or branched, the branches cornute or scyphiform, destitute of squamules or squamulose toward the base, decorticate and sorediate, or corticate toward the base and rarely also below the cups, the cavity of the cups sorediate.

This subspecies was collected at Kettle Falls and at Tower. On earth.

Not known elsewhere in North America. Frequent in Europe.

27d. *Cladonia fimbriata radiata* (Schreb.) Nyl. Syn. Lich. 1: 195. 1858.

Lichen radiatus Schreb. Spic. Fl. Lips. 122. 1771.

Podetia commonly long, 17 to 75 mm. in length, scyphiform, elongate-turbinate or subtubæform, commonly more than 1-ranked, the sterile apices cornute, subulate, or rarely obsoletely scyphiform, commonly straight and suberect, wholly decorticate and sorediate, or corticate and minutely areolate or verrucose toward the base, without squamules or rather rarely squamulose, especially toward the base; cups rather small, 2 to 5 mm. in diameter, gradually or quite abruptly dilated, quite regular or irregular, the margins dentate or proliferate, the proliferations one to several and elongated or quite short, the ranks 2 or 3; apothecia sessile or shortly stalked on the margins of the cups.

For the most part confined to the northern portion of the State, but collected as far south as Redwood Falls. On earth and old wood.

Generally distributed throughout northern North America. Known in all of the grand divisions except South America.

27e. *Cladonia fimbriata subulata* (L.) Wainio, Act. Soc. Faun. Flor. Fenn. 10: 282. 1894.

Lichen subulatus L. Sp. Pl. 1153. 1753.

Podetia much elongated, 3 to 10 cm. in length, usually cupless, cylindrical, simple or variously branched, the sterile apices obtusely cornute or subulate; erect and straight or subflexuous, especially toward the apex, wholly decorticate and sorediate, or areolate or subcontinuously corticate toward the base, without squamules or more or less squamulose, especially toward the base; apothecia at the apices of the podetia, rather rare.

Throughout the northern portion of the State. On earth, especially over rocks.

Elsewhere in North America known in the White Mountains and on Vancouver Island. Known in all of the grand divisions.

27f. *Cladonia fimbriata nemoxyna* (Ach.) Wainio, Act. Soc. Faun. Flor. Fenn. 10: 295. 1894.

Baeomyces radiatus nemoxynus Ach. Meth. Lich. 342. 1803.

Podetia commonly 25 to 90 mm. long, scyphiform or subschyphiform, 2 or 3-ranked, the sterile apices abortively scyphiform, cornute or subulate, suberect, more or less flexuous, wholly decorticate and sorediate, or in the basal half (more or less) variously areolate or verrucose-corticate, as also at the base of the apothecia and of the proliferations, without squamules or the basal portions and below the cups squamulose or rarely the whole podetium sparsely squamulose; cups small or abortive, 1 to 3.5 mm. in diameter, gradually or somewhat abruptly dilated, commonly becoming irregular, the margin dentate or proliferate, the proliferations one or more, either short or quite elongated; apothecia sessile or on pedicels on the margin of the cups.

Common throughout the northern half of the State, occurring as far south as Taylors Falls and Granite Falls. On earth, frequently over rocks.

Found elsewhere in North America in a single locality, viz, New Bedford, Massachusetts. Known in all of the grand divisions.

27g. *Cladonia fimbriata coniocraea* (Floerke) Wainio, Act. Soc. Faun. Flor. Fenn. 10: 308. 1894.

PLATE 14, B.

Cenomyce coniocraea Floerke, Deutsch. Lich. 7: 14. 1821.

Podetia rather short, commonly 5 to 25 mm. long and 1 to 2 mm. in diameter, cupless and cylindrical or abortively scyphiform, commonly simple or rarely sparsely short-branched toward the apex, the sterile apices subulate, cornute, or abortively scyphiform, commonly straight and erect but sometimes flexuous, wholly decorticate and sorediate, or corticate toward the base and rarely below the cups, the cortex subcontinuous or areolate-verrucose, without squamules or more or less squamulose, especially toward the base; cups small or abortive, 1 to 2 mm. in diameter, terminal with a usually entire and at least nonproliferate margin; apothecia scarcely rare, borne at the apex of the podetia or on the margins of the small cups, commonly sub solitary on very short pedicels.

Generally distributed over the State. Commonly on old and rotting wood.

Wainio does not give the subspecies a wide North American distribution, but it seems that the plants referred to *Cladonia fimbriata tubaeformis*, by Tuckerman belong here or to the next subspecies. This would give a general North American distribution, which doubtless exists. Known also in Europe, Asia, and Australia.

EXPLANATION OF PLATE 14.—See p. 113.

27h. *Cladonia fimbriata apolepta* (Ach.) Wainio, Act. Soc. Faun. Flor. Fenn. 10: 307. 1894.

Baeomyces bacillaris apoleptus Ach. Meth. Lich. 330. pl. 7. f. 6. 1803.

Podetia commonly quite short, cupless or narrowly or abortively scyphiform, wholly decorticate and sorediate or corticate toward the base and rarely below the apothecia.

This subspecies is perhaps rather shorter and more slender than the last, lighter in color, and more frequently squamulose. These remarks are based on the four or five specimens referred here for us by Doctor Wainio, and we admit our inability to distinguish between the two subspecies.

Confined to the northern portion of the State. On old and rotting wood.

If these two subspecies may be regarded as at all distinct, the American and foreign distribution of the two is very similar.

28. *Cladonia pityrea* (Floerke) Fr. Sched. Crit. Lich. Exsicc. Suec. 8: 21. 1826.

Capitularia pityrea Floerke, Ges. Naturf. Freund. Mag. 2: 15. 1808.

Primary thallus finally disappearing, when present composed of subdigitate, lacinate, or crenate, involute, concave or flat, ascending, clustered or scattered squamules, which are 1 to 3 mm. long and 0.5 to 2 mm. wide, sea-green or olivaceous above and white below and rarely more or less sorediate-granulose; podetia arising from the surface of the primary thallus, 3.5 to 50 mm. long and 0.5 to 4 mm. in diameter, tubaeform, turbinate, or subcylindrical, scattered or clustered in small patches, usually erect, the cortex subcontinuous and verrucose, or composed of small areoles, the areoles raised and contiguous, sometimes more or less squamulose; sea-green, varying toward ashy or olivaceous, sometimes scyphiform, the cupless and sterile apices obtuse or subulate, simple or digitately or irregularly branched; cups 0.5 to 3 mm. in diameter, gradually or abruptly dilated, commonly more or less irregular, often oblique, the cavity rather shallow, the margin dentate, lacerate, or proliferate, the proliferations one or more and the ranks 1 to 3; apothecia small or medium-sized, 0.5 to 2.5 mm. in diameter, often conglomerate, usually on short pedicels on the margins of the cups

or at the cupless apices, the disk flat and thinly margined or becoming convex and immarginate, commonly brick-red (but ours more often a dark brown); hypothecium pale or pale brownish; hymenium of same color or darker brownish above; paraphyses simple or branched, commonly thickened and brownish toward the apex; asci clavate or cylindrico-clavate.

A single collection from Granite Falls has been placed here by Doctor Wainio, who would refer all well-marked specimens to one of his several forms. On earth.

Recorded by Wainio from several widely separate North American localities and no doubt quite generally distributed, though little known in America. Known in all of the grand divisions and a very widely distributed lichen.

28a. *Cladonia pityrea subacuta* Wainio, Act. Soc. Faun. Flor. Fenn. 10: 355. 1894.

Podetia cupless, only 10 to 35 mm. in length, wholly granulate or sorediate-granulate, or verrucose or areolate-corticate toward the base, seldom bearing squamules.

Part of the material of the same collection has cups, and this Doctor Wainio has referred to subspecies *cladomorpha* (Floerke) Wainio, loc. cit. The material is otherwise wholly similar.

Collected at Emo. On old wood.

Neither form is known elsewhere in North America. Both are more or less common in Europe.

29. *Cladonia botrytes* (Hag.) Willd. Fl. Berol. Prodr. 365. 1787.

Lichen botrytes Hag. Tent. Hist. Lich. 121. pl. 2. f. 9. 1782.

Primary thallus commonly persistent, composed of crenate, incised or variously laciniate, flat, involute or rarely convex, commonly ascending, scattered or rarely clustered squamules, these 1 to 3 mm. long and of about the same width, sea-green, varying toward straw-colored or olivaceous above and white below, sometimes sparsely sorediate or granular; podetia arising from the surface of the squamules, 2 to 18 mm. long, rather slender, cylindrical or subcylindrical, rarely abortively scyphiform, variously branched toward the apex, or simple, or rarely branched toward the base, the branches commonly short or very short, the sides frequently rimose, the axils sometimes open; solitary or in groups, erect or variously curved or flexuous, the cortex verrucose or divided into rather small areoles, these contiguous or scattered, sometimes more or less squamulose, especially toward the base; varying from straw-colored to sea-green, or the decorticate portions straw-colored or whitish; cups rare and abortive, in the axils of branches when present; apothecia terminating all of the podetia or branches, small or rarely middle-sized, commonly 0.4 to 2 mm. in diameter, rounded or irregular, sometimes perforate, frequently clustered or conglomerate, rarely solitary, flat, and margined with a light-colored exciple, or more commonly convex and immarginate, from pale flesh-colored to pale brown, rarely somewhat pruinose; hypothecium pale; hymenium pale throughout or slightly colored above; paraphyses simple, the apex frequently thickened but showing little or no color; asci clavate or cylindrico-clavate.

Throughout the northern portion of the State. On old wood, especially of conifers. Easily passed over as a condition of *Cladonia cariosa* or *Cladonia mitrula*.

Plants from British Columbia, Wisconsin, and New York had been previously referred here by Wainio. Common in Europe and known also in Asia.

Family STEREOCAULACEAE.

The family consists of the two genera *Pilophorus* and *Stereocaulon*. The structure of the thallus and the apothecia will be thoroughly discussed under *Stereocaulon* following, and the family may, for the rest, be disposed of rather briefly.

The relationship of the Stereocaulaceae to the Cladoniaceae in the possession of a primary and a secondary thallus and in apothecial characters is obvious. Indeed, the two families are seldom separated, and if we consider the apothecial characters alone there is certainly no reason for a division. But if we look at the secondary thallus (podetia) of Stereocaulon and Pilophorus closely it will appear that there is doubt as to whether any of the algæ found in the phyllocladia, or even those rarely found in the loose network of hyphæ, are other than foreign. The absence of a cortex would render the capture of foreign algæ by the outer hyphal layer and the phyllocladia an easy matter, and perhaps we have here, after all, at best only what may be regarded as pseudopodetia. Also the phyllocladia are certainly totally different structures from the squamules of the podetia of the Cladonias, but this of itself would give us no more ground for making two families for Cladonia and Stereocaulon than we should have for separating *Peltigera aphthosa* from the Peltigeraceae on account of the cephalodia. Further studies of the podetia must decide whether or not Stereocaulon and Pilophorus may properly be included with the Cladoniaceae. And, indeed, the relationships can scarcely be understood until we know more of the phylogeny of the genera involved. Also, the relative rank of the genera can hardly be decided at present.

STEREOCAULON ^a Hoffm. Deutsch. Fl. 2: 128. 1795.

PLATE 18.

The thallus, as in Cladonia, consists of a primary and a secondary. The primary thallus, however, is wanting in the mature plant, so that in the descriptions it may be neglected. The secondary thallus is conspicuous and permanent, composed of the podetia. The podetia are fruticose structures, much branched, the whole podetium being variously twisted and irregular. The central portion of each branch of the podetium is composed wholly of hyphæ extending for the most part longitudinally and forming a solid cylinder, immediately surrounding which is a tangled mass of hyphæ, which may be regarded as a medulla. Surrounding this medullary tissue on all sides is a looser layer of hyphæ inclosing the algal cells and extending outward in all directions as warty or isidioid outgrowths, the so-called phyllocladia. There is no cortex in any of the species. Several kinds of algal cells may be looked for even in the same species. All, however, except perhaps *Cystococcus*, which is the most constantly present, may be regarded as foreign. A discussion regarding other algæ present may be found in Schneider's Text-Book of Lichenology.

The apothecia are usually small or of medium size. They are located on the ends of the branches, and are convex or globose, or sometimes quite flattened. The proper exciple commonly disappears. The hypothecium is pale. The hymenium is pale or brownish below and commonly brownish or brown above. The paraphyses are rarely branched. The spores are hyaline, fusiform to acicular, and 4 to several-celled.

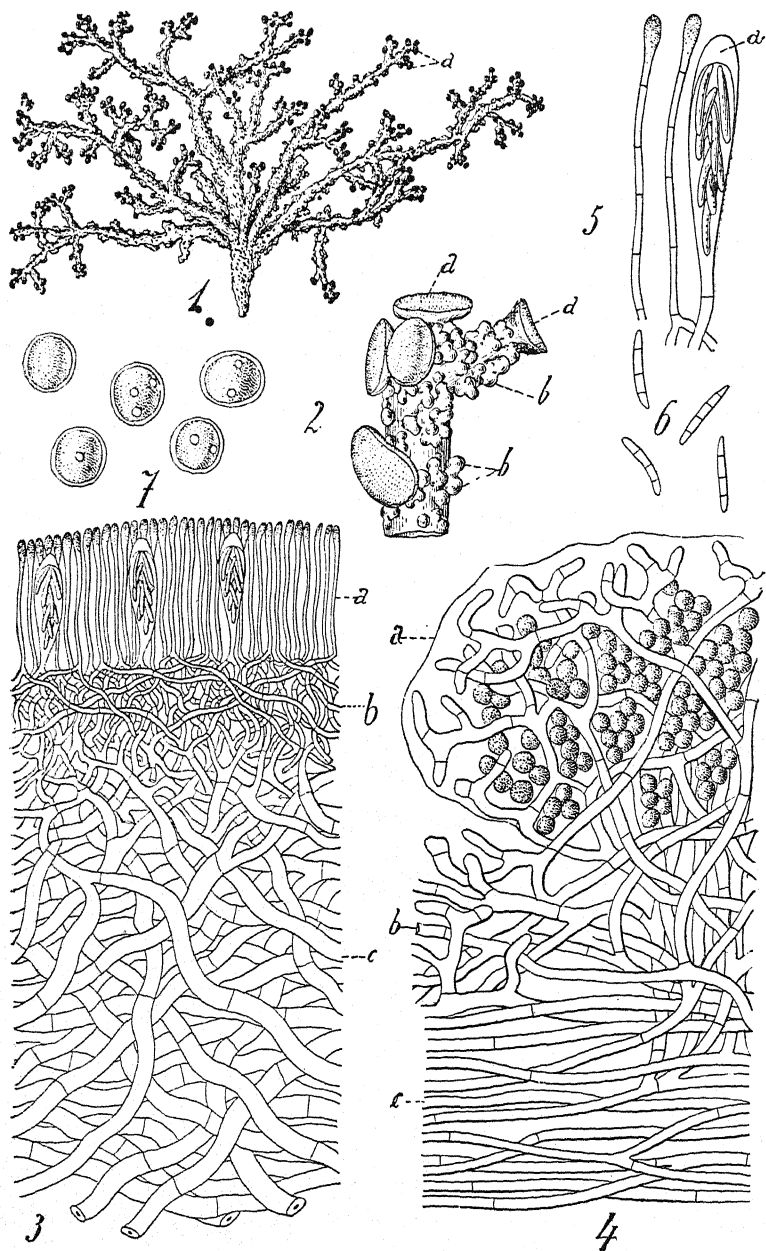
The members of the present genus seem to be closely related to the Cladonias, though apparently still more nearly related to Pilophorus.

Three species have been reported from the State. On earth over rocks, frequently a very thin layer of humus on a flat rocky surface or in a crevice.

Type species *Stereocaulon corallina* (Wulf.) Hoffm. op. cit. 129.

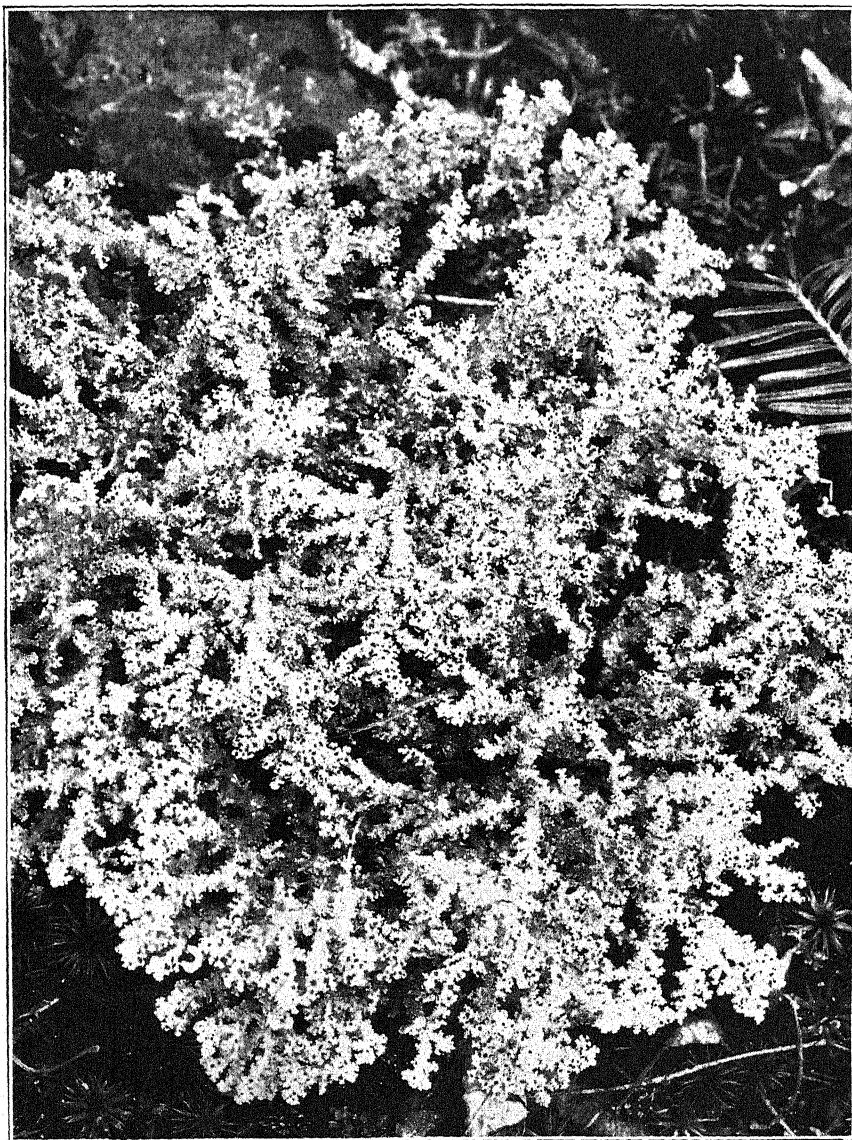
EXPLANATION OF PLATE 18.—Fig. 1, part of a plant. Fig. 2, *a*, the apothecia; *b*, the phyllocladia. Fig. 3, a section of the apothecium and a portion of the thallus; *a*, the hymenium; *b*, the hypothecium; *c*, the medullary layer. Fig. 4, a longitudinal radial section of a podetium; *a*, a phyllocladium; *b*, the external loose network of hyphæ; *c*, the internal mechanical tissue of longitudinal hyphæ. Fig. 5, paraphyses and (•) an ascus. Fig. 6, free single spores. Fig. 7, algal cells. Fig. 1, natural size; fig. 2, enlarged about 10 diameters; figs. 3, 4, enlarged 300 diameters; figs. 5-7, enlarged 650 diameters. From Schneider.

^aThe original spelling is followed.



STEREOCAULON CORALLOIDES FR.

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STEREOCAULON TOMENTOSUM FR.

KEY TO THE SPECIES

- Branches of the podetia smooth and naked below..... 1. *S. coralloides*.
 Branches of the podetia not always smooth and naked below.
 Branches of the podetia often slightly tomentose between
 the phyllocladia..... 2. *S. paschale*.
 Branches of the podetia densely white-tomentose..... 3. *S. tomentosum*.

1. *Stereocaulon coralloides* Fr. Sched. Crit. Lich. Exsicc. Suec. 4: 24. 1827.

PLATE 18.

Podetia erect or ascending, occurring in dense clusters, 3 to 7.5 cm. long, rather slender and irregularly compressed-cylindrical, much branched above, smooth and naked below, sea-green varying toward ashy or brownish; phyllocladia more or less scattered, ashy-whitish, passing into digitately divided, coralloid, commonly crowded branchlets; apothecia small to middle-sized, 0.3 to 2 mm. in diameter, terminal or subterminal and often more or less clustered, the disk commonly brown, at first flat and surrounded by the lighter-colored exciple, but becoming convex and the exciple disappearing; hypothecium pale; hymenium pale or brownish below and darker above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate or narrowly-clavate; spores commonly 4-celled, 20 to 35 μ long and 3 to 4.5 μ wide.

Collected on Carlton Peak. On humus over rocks.

In the mountains of New England and South Carolina, and common northward throughout British America. Known also in Europe and Asia.

2. *Stereocaulon paschale* (L.) Hoffm. Deutsch. Fl. 130. 1795.

Lichen paschalis L. Sp. Pl. 1153. 1753.

Podetia erect, ascending, or subdecumbent, somewhat longer than those of the last, 3.5 to 10 cm. long, usually rather slender, but somewhat stouter than those of the last, occurring in dense clusters, the clusters sometimes 20 cm. in diameter, more or less compressed and somewhat irregularly cylindrical, slightly tomentose or nearly naked, much branched; phyllocladia ashy or varying toward sea-green, passing into short squamulose and crenate branchlets; apothecia terminal or subterminal, on the whole somewhat larger than in the last, brown or reddish brown, the disk flat and with lighter proper exciple or becoming more or less convex and the exciple disappearing; hypothecium pale; hymenium commonly of the same color below and brownish above, or both hypothecium and hymenium darker; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores much as in the last, but becoming more than 4-celled more frequently.

Distributed throughout the northern portion of the State and once collected as far south as Redwood Falls. On humus over rocks.

Found in New England and northward throughout British America and Alaska. Known in Europe and Asia.

3. *Stereocaulon tomentosum* Fr. Sched. Crit. Lich. Exsicc. Suec. 3: 21. 1827.

PLATE 19.

Podetia of about the same length as those of the last, but commonly stouter and somewhat more regularly cylindrical, also rather more loosely tufted and even sub-solitary, densely whitish-tomentose, divaricately branched, the branches much divided above; phyllocladia grayish white or perhaps more commonly varying toward greenish, becoming squamule-like and blunt-toothed or finger-lobed, crowded on the upper side, but almost wanting beneath; apothecia in ours at least rather smaller or even minute, scarcely reaching more than 0.75 mm. in diameter, subterminal or lateral, frequently more or less clustered, the disk brown, at first flattish and surrounded by the exciple, soon becoming convex and the exciple disappearing; hypothecium pale; hymenium pale or brownish below and darker above; paraphyses

simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate or cylindrico-clavate; spores as in the first species, or sometimes a little narrower.

Collected on Oak Island in Lake of the Woods and on Grand Portage Island. On earth over rocks.

Found in mountainous regions in the United States, as the mountains of New England, the Rocky Mountains, and Mount Hood (Oregon), and in the mountains of Mexico. Also generally distributed in British America and Alaska. Known also in South America, Europe, and Asia.

EXPLANATION OF PLATE 19.—Plant on rocks; a top view giving an undue depressed appearance, but showing the much-branched podetia covered with phyllocladia and the apothecia. Natural size.

PILOPHORUS Th. Fr. Ster. Pil. Comm. 40. 1857.

The thallus, like that of *Cladonia* and *Stereocaulon*, consists of primary and secondary, but the primary is very poorly developed, consisting of a verrucose crust which is so inconspicuous and evanescent that no account is usually taken of it in descriptions of species. The podetia forming the secondary thallus are simple or very sparingly branched. The central portion of each podetium is composed of a loose network of hyphae, which may fill the whole center of the cylinder, or may be absent from the axial line, leaving the podetium hollow at the center. Immediately surrounding this central portion is the mechanical tissue, consisting of densely packed hyphae extending longitudinally. The podetia are without cortex and are clothed more or less with phyllocladia containing the algae, which are of the genus *Cystococcus*.

The apothecia are small or of medium size and are globose, subglobose, or elongated. They are terminally disposed upon the podetia and are black externally. The hymenium is also black and very tough and stout. The paraphyses are black or bluish black tipped. The spores are hyaline, simple, ellipsoid or fusiform.

The genus differs from *Stereocaulon* mainly in point of the dark and tough character of the apothecia and in having simple spores.

A single species has been found in the State.

Type species *Pilophorus robustus* Th. Fr. op. cit. 41.

1. *Pilophorus cereolus* (Ach.) Tuck. Syn. N. A. Lich. 1: 235. 1882.

Lichen cereolus Ach. Lich. Suec. 89. 1798.

Podetia erect, rigid, cylindrical or subcylindrical, simple or rarely bearing 2 to 5 branches, clustered or scattered over the substratum, short and stout or more slender and elongated, 5 to 40 mm. long, the apex often subulate in sterile specimens, solid or rarely hollow; phyllocladia minute, rounded or becoming flattened and squamule-like, sea-green to ashy or rarely olivaceous; apothecia about 1.5 mm. in diameter, subglobose; spores fusiform, 17 to 20 μ long and 5 to 7 μ wide.

Ours is sterile and the apothecial and spore characters are taken from Nylander.

Collected on rocks at Grand Marais. Not previously reported from Minnesota.

Widely distributed in the northern United States and British America. Known also in Asia, Australia, and Africa.

Family COLLEMACEAE.

This family is one of the best defined groups of lichens, being quite distinct from any other group, both in the structure of the thallus and in the character of the algal symbiont.

The thallus is foliose, but either has no cellular cortex or possesses a single layer of cells above and one below. Nor are the internal layers well differentiated, the algal cells being scattered throughout the thallus, except in the single-layered cortex when this structure is present. In all of ours the algal symbiont is a form of *Nostoc*, and the heterocysts are easily made out. The thallus is more or less gelatinous when wet in all of our species, a condition due to a swelling of the gelatinous sheath of the algal

filaments. The fungal hyphae frequently lie in contact with the sheath of the algal filaments, but there are no haustoria, and the relation of the two symbionts is not so close as in most other lichens. The thallus is peculiar in two of the genera in being foliose in form and still without cortex, in this respect like crustose thalli. The foliose condition here is of course due to the peculiar nature of the algal symbiont, which quite largely determines the form of the thallus.

The apothecia more commonly show a thalloid exciple, but are on the whole more nearly biatoroid than those of any family following. The family is, therefore, placed near the Lecideaceae, though there is much room for difference of view as to the relative position of the present family and several to follow. However, as to spore characters some of the families next to follow seem lower than the present one. With respect to the spores, the Collemaeae seem nearest to the Pannariaceae.

SYNECHOBLASTUS Trev. Caratt. Gen. Collem. 2. 1853.

The thallus is foliose, but is frequently extended above into marginal or submarginal rugose lobes which give a cespitose-fruticose appearance, sometimes wholly obscuring the horizontal portion even to the center of the thallus. In the higher forms of the genus, the thallus is quite expanded. The cortical layers of the thallus are wholly absent, nor is there any distinct algal layer. On the other hand, the algæ, which consist of a species of *Nostoc*, showing the heterocysts plainly, are scattered throughout the entire thallus. The algæ occur in chains, which are rather more numerous toward the upper surface of the thallus, or not infrequently quite as numerous toward the lower sides. The chains of algal cells are easily distinguishable, though possibly on the whole hardly so long as in *Collema*. The color of the thallus is bluish, olivaceous, or black, and usually lighter below than above. The thallus may be attached to the substratum by direct adhesion of the lower surface or by rather sparingly developed simple rhizoids.

The apothecia are rather small and are ordinarily developed in all but one of our species. The thalloid exciple is commonly present and extends somewhat above the disk. The color of the disk is generally brown or brownish black, and it is usually flat or slightly convex. The hypothecium is commonly pale or pale brownish, and the hymenium pale below and brownish above. The paraphyses are ordinarily simple, though branched forms may be found in all the species. The spores are hyaline, from 2 to several-celled, but never muriform.

We have divided the genus *Collema* as conceived by Tuckerman, placing in that genus those species having more or less muriform spores and in the present one those not so divided. There seems to be a gradual evolution of spore characters running through the two genera, which are very closely related. The relation of both genera to *Leptogium* is also a close one, *Collema*, as to spore characters at least, seeming to be intermediate between the other two.

A half dozen forms occur in the State. On trees and more rarely on rocks.

Type species *Collema nigrescens* (Huds.) Ach. loc. cit. (*Synechoblastus nigrescens* (Huds.) Stizenb.)

KEY TO THE SPECIES.

Thallus lobes quite closely attached to the substratum.

Spores several-celled, long and narrow; apothecia pruinose.. 4a. *S. nigrescens leucopeplus*.

Spores as above; apothecia not pruinose..... 4. *S. nigrescens*.

Thallus lobes not closely attached to the substratum.

Erect or nearly so.

Spores 2-celled..... 1. *S. pycnocarpus*.

Spores 4-celled..... 2. *S. cyrtaspis*.

Ascending.

Spores 4 to 6-celled, rather short and wide..... 3. *S. flaccidus*.

Spores 4 to 8-celled, longer and narrower..... 5. *S. ryssoleus*.

1. *Synechoblastus pycnocarpus* (Nyl.) Fink.

Collema pycnocarpum Nyl. Syn. Lich. 1: 115. 1858.

Thallus foliose and suborbicular, middle-sized, 15 to 65 mm. in diameter, sometimes ribbed and here and there perforate, the lobes long and more or less branched and rising at the margins into a usually erect position, the erect portions densely and rugose-lobulate, more or less obscuring the flat parts below, especially when, as at length, covered with the apothecia; adhering to the substratum and also attached by scattered rhizoids, greenish, olivaceous, or blackish, lighter colored below; algal chains distinctly more numerous toward the upper and lower surfaces; apothecia small, 0.4 to 1 mm. in diameter, sessile, the disk brown or reddish brown, becoming convex and irregular and sometimes covering the thalloid exciple, this, when present, having an entire margin; hypothecium commonly pale; hymenium pale below, and pale brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores 2-celled, ovoid-ellipsoid, 11 to 16 μ long and 4 to 6.5 μ wide.

Hardly a common Minnesota lichen, but widely distributed in the State. On tree trunks.

Widely diffused in the United States east of the Rocky Mountains and northward into Canada. A strictly American plant, known also in South America.

Collema pycnocarpum of the preliminary reports.

2. *Synechoblastus cyrtaspis* (Tuck.) Fink.

Collema cyrtaspis Tuck. Proc. Amer. Acad. 5: 387. 1862.

Thallus quite similar to that of the last, but on the whole larger and more distinctly lobed, the coloration as above; apothecia said to be larger, reaching 2 mm. in diameter, and more scattered, the thalloid margin more persistent and commonly crenulate; spores 4-celled.

It is the last character which more than any other seems to separate the species from the last above.

Determined from Vermillion Lake by H. Willey. On tree trunks. We have not examined the plant microscopically.

Quite widely distributed throughout the eastern half of the United States and northward into Canada. Not known elsewhere.

Collema cyrtaspis of the preliminary reports.

3. *Synechoblastus flaccidus* (Ach.) Trev. Caratt. Gen. Collem. 1853.

Lichen flaccidus Ach. Vet. Akad. Handl. 16: 14. 1795.

Thallus foliose and suborbicular, middle-sized, 2 to 7 cm. in diameter, somewhat more loosely attached to the substratum than other species (disregarding, of course, the erect lobes of the last two species), and scarcely so gelatinous when wet as the two above; composed of rather wide, rounded, entire lobes, these more or less imbricate and clothed frequently with granules of the same color as the thallus, the color above olivaceous, commonly varying toward black and less frequently toward greenish, usually lighter below; rhizoids few and weak and the plants more usually adhering to the rocks; algal cells slightly more numerous toward the upper surface; apothecia small and sessile, seldom present in ours, 0.5 to 1 mm. in diameter, the disk reddish brown, flat or convex, the margin entire and frequently granulate; hypothecium pale to brownish; hymenium pale below and brownish yellow above; paraphyses simple or rarely branched, the apices usually enlarged and brownish; asci clavate; spores 4 to 6-celled, fusiform-oblong, 20 to 26 μ long and 6 to 8 μ wide.

Generally distributed over the State, but not common anywhere. On trees and rarely on rocks.

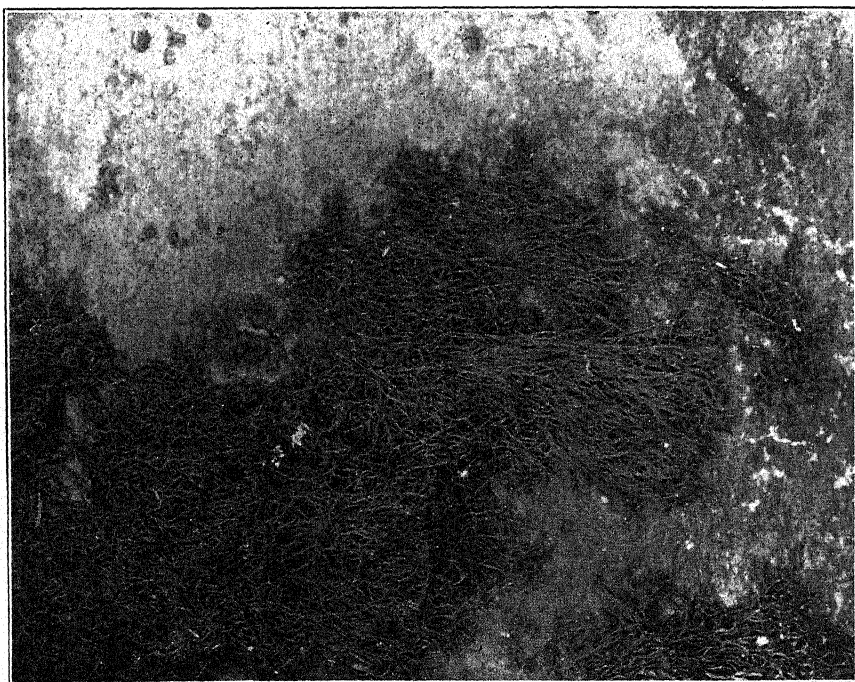
Widely distributed in North America. Common also throughout Europe.

Collema flaccidum of the preliminary reports.





A. SYNECHOBLASTUS NIGRESCENS (HUDS.) STITZENB.



B. EPHEBE PUBESCENS (L.) FR.

4. *Synechoblastus nigrescens* (Huds.) Stizenb. Ber. St. Gall. Ges. Naturw. 1861-62: 144. 1862.

PLATE 20, A.

Lichen nigrescens Huds. Fl. Angl. 450. 1762.

Thallus foliose and commonly orbicular, middle-sized, 30 to 75 mm. in diameter, closely adnate, rather thin, closely beset with pustules on many of which are commonly situated apothecia, or the pustules largely absent and replaced by radiating ridges, the short, rounded marginal lobes entire and usually more or less raised; olivaceous-green and blackening, below lighter and marked by depressions corresponding to the pustules or ridges of the upper surface; algal cells rather more numerous toward the upper surface, rhizoids few and weak and scarcely of use as attaching organs; apothecia small, 0.5 to 1.25 mm. in diameter, sessile, frequently numerous and nearly obscuring the thallus, the disk brown or reddish brown, becoming convex, the thin margin sometimes disappearing; hypothecium pale; hymenium pale below and brownish above; paraphyses simple, or rarely branched toward the frequently enlarged and brownish apex; asci clavate; spores long-fusiform and acicular, several-celled, 50 to 72 μ long and 4 to 6.5 μ wide.

Confined to the northern portion of the State. On trees, especially poplars.

Widely distributed in North America. Known in all the grand divisions except South America.

Collema nigrescens of the preliminary reports.

EXPLANATION OF PLATE 20.—A, plant of *Synechoblastus nigrescens* on poplar, showing the foliose thallus and the rather inconspicuous apothecia. B, plant of *Ephêbe pubescens* on rocks, showing the fruticose thallus, whose form is determined by the algal symbiont *Strosiphon*.^a A and B enlarged 2½ diameters.

- 4a. *Synechoblastus nigrescens leucocephalus* (Tuck.) Fink.

Collema nigrescens leucocephala Tuck. Gen. Lich. 92. 1872.

Apothecia white-pruinose, said to be smaller, as also the whole plant. Ours scarcely distinct and possibly not the subspecies.

Frequent in the northwestern portion of the State, along the boundary especially. On trees.

A North American form, previously reported from several southeastern States. Ours quite as distinct as the material distributed in "Lichenes Boreali-Americani," number 114, from South Carolina.

Collema nigrescens leucocephala of the preliminary reports.

5. *Synechoblastus rysssoleus* (Tuck.) Fink.

Collema nigrescens rysssoleum Tuck. Lich. Calif. 34. 1866.

Thallus commonly orbicular, less closely attached to the substratum than the last, in the material at hand 20 to 45 mm. in diameter, rather smooth above, the rounded lobes ascendant with plicate-undulate and crisped margins, rugose-papulose above; olivaceous or at length blackish brown, beneath paler and reticulate-lacunose; algal cells rather more numerous toward the upper surface; rhizoids few and weak, and the gelatinous thallus here and there directly adnate to the substratum; apothecia small, 0.5 to 1.5 mm. in diameter, sessile, scattered or crowded, the disk brown or reddish brown, flat or convex, the thin entire margin sometimes disappearing; hypothecium pale brownish; hymenium pale below and brownish above; paraphyses simple or branched toward the apex, there also frequently thickened and brownish; asci clavate; spores ovoid and becoming subacicular, 4 to 8-celled, 22 to 26 μ long and 5 to 7 μ wide.

Collected on poplar at Bemidji. The material was scanty and the habitat unusual for the species, but the plant was more like the present externally, and the spore measurements preclude its belonging to the last above.

Otherwise known throughout the eastern United States and as far west as Ohio. Not found recorded for any locality outside of the United States.

Collema rysssoleum of the preliminary reports.

^a See footnote, p. 23.

COLLEMA (Hill.) Web. in Wig. Prim. Fl. Hols. 89. 1780.

PLATE 21.

The thallus is foliose and, like the last, is inclined to be irregular, though on the whole somewhat orbicular. Taken all together, the thalli of the members of the genus are the most gelatinous of all lichen thalli. As in the last, also, the cortical layers are entirely wanting, nor is there a distinct algal layer. The algæ are plainly forms of the genus *Nostoc*, and the heterocysts may usually be plainly seen. The chains of algal cells are quite long and variously curved, and are commonly somewhat more numerous toward the upper side of the thallus. The common color is bluish-olivaceous or blackish. The attachment of the thallus is as in the last genus.

The apothecia are on the whole larger than those of the last genus and are hardly so numerous, though found more or less frequently in all of our species. A thalloid exciple is commonly present and extends somewhat above the margin of the disk. The common color of the disk is some shade of brown, and it may be flat, concave, or convex. The hypothecium is pale or brownish as is also the hymenium. The paraphyses are commonly simple, but branched ones may be found in any of the species. The spores are commonly pale or hyaline, though always more or less muriform when fully mature.

The genus is intermediate between *Synechoblastus* and *Leptogium*, but much closer to the former genus, with which it agrees as to thallus structure. As regards the spores, however, it is perhaps nearer to the latter.

Seven forms have been reported from the State. On earth, or more rarely on rocks or over mosses. Found in moist places.

Type species *Collema lactuca* Web. loc. cit. This is the same as *Synechoblastus nigrescens* (Huds.) Stizenb., hence *Collema* must in all probability replace *Synechoblastus*, and some other name be substituted for it in its present acceptance.

EXPLANATION OF PLATE 21.—Fig. 1, a plant showing the thallus and the apothecia. Fig. 2, a lobe of the thallus with apothecia. Fig. 3, a section of an apothecium; *a*, the hymenium; *b*, the hypothecium; *c*, the inner thallus with hyphæ and algal filaments; *d*, the ventral horizontal hyphæ; *e*, the rhizoids. Fig. 4, a section of the thallus; *a*, the algal filaments; *b*, the fungal hyphæ; *c*, algal filaments; *d*, the rhizoids. Fig. 5, a paraphysis and an ascus. Fig. 6, free muriform spores. Fig. 7, algal filaments. Fig. 1, natural size; fig. 2, enlarged about 4 diameters; figs. 3, 4, enlarged 400 diameters; figs. 5-7, enlarged 650 diameters. From Schneider.

KEY TO THE SPECIES.

On rocks.

- Thallus lobes somewhat broad and short, rounded..... 6. *C. furvum*.
 Thallus lobes narrower and longer.
 Apothecia sessile or subpedicellate on the somewhat
 narrowed and ascending lobes..... 5. *C. plicatile*.
 Apothecia adnate on the narrower, often ascending
 lobes..... 7. *C. pustulatum*.

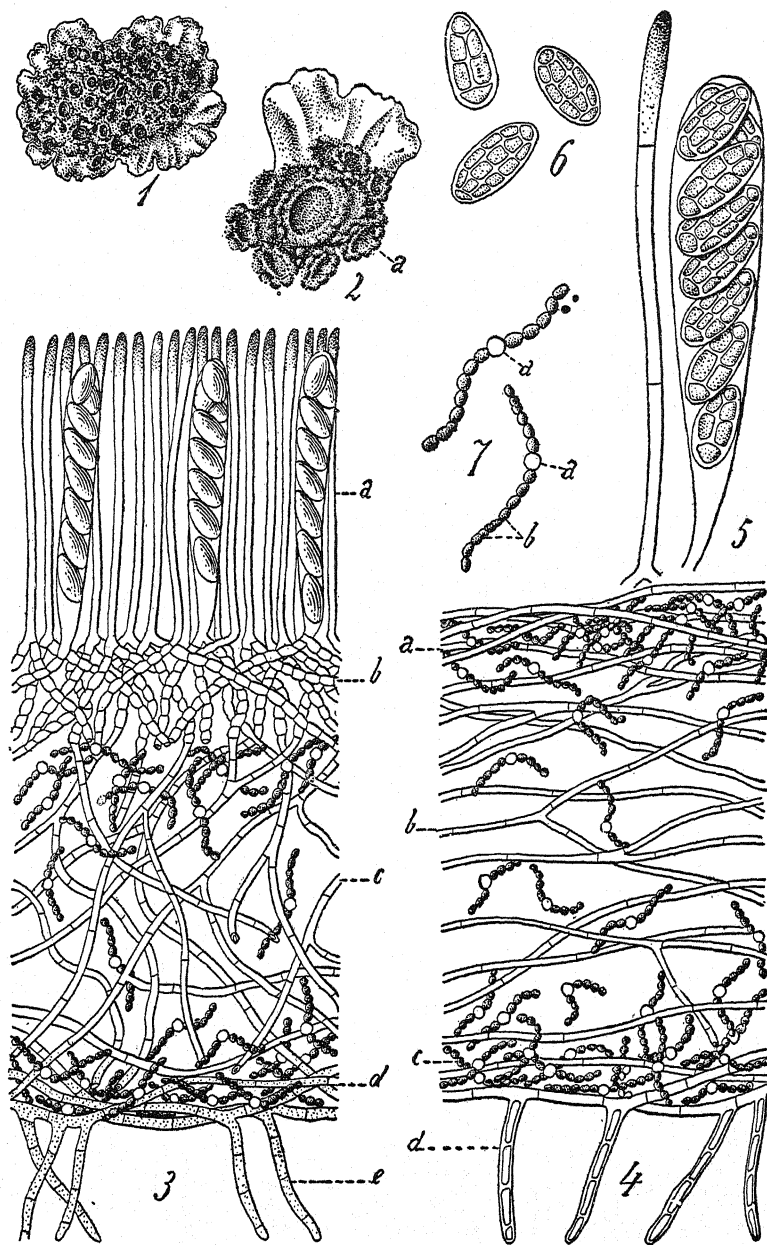
On earth.

- Thallus rather thick (rarely on mossy rocks)..... 1. *C. pulposum*.
 Thallus thinner.
 Spores usually four in each ascus..... 4. *C. limosum*.
 Spores eight in each ascus.
 Apothecia numerous, not often deeply immersed.... 3. *C. crispum*.
 Apothecia fewer and more often deeply immersed. 2. *C. tenax*.

1. *Collema pulposum* (Bernh.) Ach. Lich. Univ. 632. pl. 14. f. 9. 1810.

Lichen pulposus Bernh. Journ. Bot. Schrad. 1799¹: pl. 1. f. 1. 1799.

Thallus usually more or less orbicular, middle-sized, 15 to 80 mm. in diameter, very gelatinous when wet, frequently showing a rosulate arrangement of the lobes or granules; rather thick, the thick lobes repand-crenate and often imbricated, especially toward



COLLEMA PULPOSUM (BERNH.) ACH.

the center where the thallus is thicker, the margins somewhat explanate, the central lobes frequently reduced to mere granules; leek-green, olivaceous, or blackening above and scarcely lighter below; rhizoids few and weak; algal cells quite prominently aggregated toward the top and bottom of the thallus; apothecia small or middle-sized, adnate or more or less immersed, 0.75 to 2.5 mm. in diameter, the disk commonly flat or concave, reddish brown, the thalloid margin entire or rarely crenate; hypothecium pale or brownish; hymenium pale below and pale brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores ovoid-ellipsoid, from 4-celled becoming somewhat muriform, pale or hyaline, 17 to 25 μ long and 8 to 12 μ wide.

Generally distributed over the State. On earth or mossy rocks, more common in calcareous regions.

Widely distributed in North America, and still not reported from a large number of localities. Known also in Asia, Europe, and Africa.

2. *Collema tenax* (Sw.) Ach. Lich. Suec. 128, 237. 1798.

Lichen tenax Sw. Nov. Act. Soc. Sci. Ups. 4: 249. 1784.

Thallus usually more or less orbicular, rather thin, the lobes expanded and closely adnate, or rarely becoming more or less raised and complicate, yellowish-green or darkening; rhizoids as in the last, but the algal cells less distinctly aggregated toward the top and bottom of the thallus; plant commonly of about the same size as the last, but the thallus of ours usually very small and poorly developed; apothecia smallish, 0.5 to 2 mm. in diameter, commonly more or less immersed in the thallus, the disk usually flat or concave, reddish brown, the thalloid margin entire or crenate; hypothecium brownish; hymenium pale below and brownish above; paraphyses simple or rarely branched, commonly thickened and brownish toward the apex; asci clavate; spores as in the last.

Hardly more than a subspecies of the last.

A single collection has been made in the State at Mankato. On earth.

Distributed throughout the eastern half of the United States and northward into British America. Known also in Europe.

3. *Collema crispum* (Huds.) Hoffm. Deutsch. Fl. 2: 101. 1795.

Lichen crispus Huds. Fl. Angl. 447. 1762.

Thallus more or less orbicular, in ours smallish, 15 to 30 mm. in diameter, rather thin, the marginal lobes somewhat expanded, those of the center with raised plicate and dentate-granulate edges; olivaceous varying toward green or darker color; rhizoids few and the thallus adhering to the substratum; algal cells more or less aggregated toward the top and bottom of the thallus; apothecia frequently numerous and nearly concealing the central portion of the thallus, small or middle-sized, 0.8 to 2.5 mm. in diameter, less inclined to be immersed, the disk more or less concave, dark reddish brown, the margin crenate-granulate or more rarely entire; hypothecium brownish; hymenium pale below and brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores oblong-ellipsoid, pale or hyaline, from 4-celled becoming more or less muriform, 16 to 30 μ long and 8 to 12 μ wide.

The apothecia are deeply concave in ours. Like the last, the present is closely related to the first species, of which it may be regarded as a subspecies.

Collected at Bemidji and on the islands belonging to the United States in Lake of the Woods. On earth.

Throughout the northern half of the United States from Colorado eastward, and extending across the continent in British America. Known also in Europe, where it is usually regarded as a form of *Collema pulposum*.

4. *Collema limosum* Ach. Lich. Suec. 126, 236. 1798.

Lichen limosus Ach. Lich. Suec. 126. 1798.

Thallus thin, in ours usually consisting of scattered and inconspicuous greenish to olivaceous squamules, these usually more or less obscured by the apothecia, sometimes becoming larger and lobate, the lobes then dentate-crenate or narrowed into ascending, blunt lobules; rhizoids few, the algal cells more numerous toward the top and bottom of the thallus, when best developed, rather smaller than those of the last; apothecia commonly immersed, but becoming superficial, smallish or becoming larger than in the last, 1 to 3 mm. in diameter, the disk reddish brown, usually flat, the thalloid margin rather thin and prominent; hypothecium brownish; hymenium pale below and brownish above; paraphyses simple or rarely branched, enlarged and brownish toward the apex; asci clavate; spores pale, muriform-multilocular, 23 to 37 μ long and 10 to 14 μ wide, commonly 4 in each ascus.

Collected at Bemidji and at Koochiching. On earth.

Distributed across North America, but not known in the southern portion of the United States. Known also in Europe and Asia.

5. *Collema plicatilis* Ach. Lich. Suec. 129, 237. 1798.

Lichen plicatilis Ach. Vet. Akad. Handl. 16: 11. pl. 1. f. 2. 1795.

Thallus irregular or suborbicular, small, ours from 5 to 25 mm. in diameter, rather thicker than that of the last two, the more or less imbricated lobes usually ascending or erect with plicate-crested margins, dark-green or more commonly blackening, or rarely dark olivaceous and scarcely lighter below; rhizoids very few and the thallus only attached toward the center or at one side; algal cells more numerous toward the top or in the more erect portions toward both surfaces; apothecia small, 0.4 to 1 mm. in diameter, frequently short-pedicellate, the disk brown and darkening, commonly more or less concave, the margin entire; hypothecium brownish; hymenium pale below and brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the top; asci clavate; spores ovoid-ellipsoid, pale, more or less muriform, 18 to 28 μ long and 6 to 8 μ wide.

Collected at Mankato. On calcareous rocks.

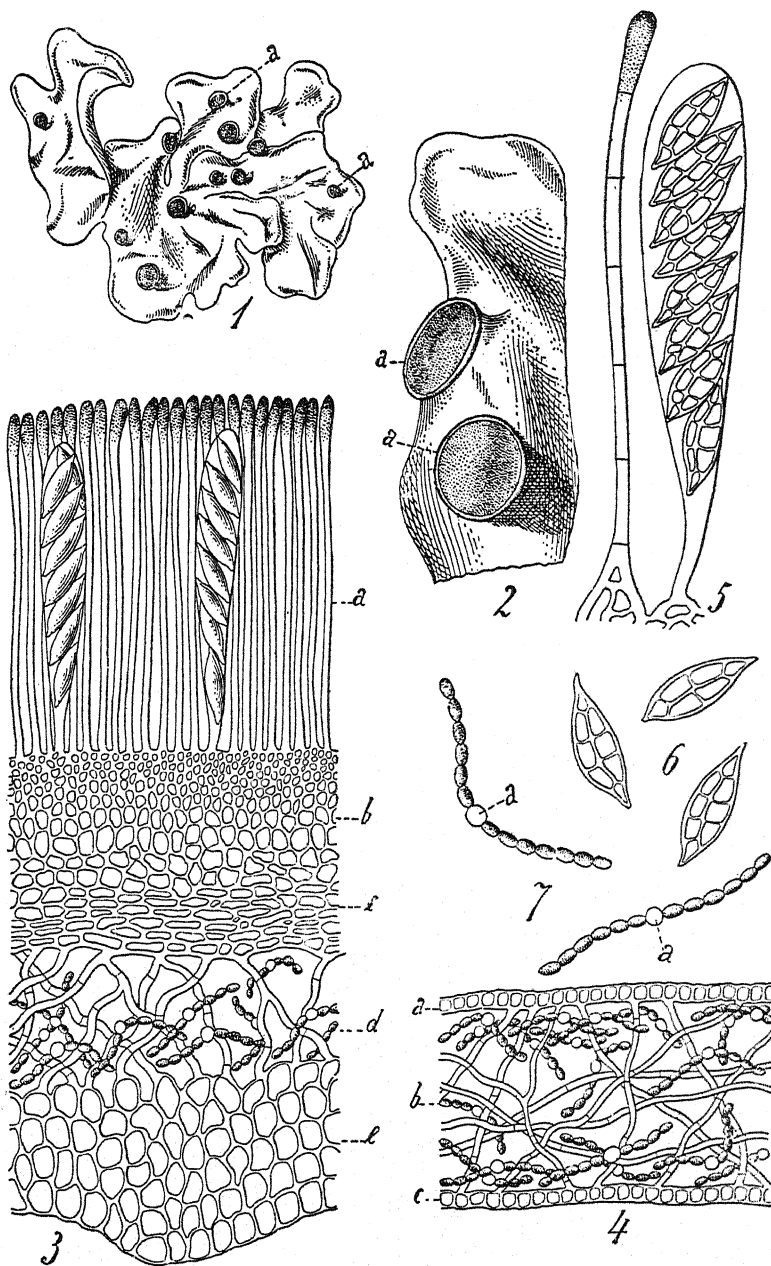
The species was reported from Iceland by Tuckerman, and H. E. Hasse records it from California. The writer has found it also in Iowa. The specimens so reported are in each case differently named. The synonymy must at best be regarded as very uncertain. Known also in Europe and Africa.

6. *Collema furvum* Ach. Lich. Suec. 132, 236. 1798.

Lichen furvus Ach. Lich. Suec. 132. 1798.

Thallus orbicular or irregular, small or middle-sized, 10 to 50 mm. in diameter, frequently scattered or the central portions falling away, olivaceous-green and blackening, usually somewhat lighter below, the upper surface becoming covered with granules of the same color as itself, the lobes rounded or somewhat irregular, with entire, undulate or crenulate and more or less crisped margins, frequently becoming somewhat elongated, ascending or suberect; attachment of thallus much as in the last, or more of the lower surface adhering to the substratum; algal cells somewhat more numerous toward the upper side; apothecia usually few and scattered, small, 0.5 to 1 mm. in diameter, sessile, the disk brown and darkening, flat or concave, the thalloid margin entire; hypothecium brownish; hymenium pale or pale brownish below and brownish above; paraphyses simple or rarely branched, frequently enlarged and brownish toward the apex; asci clavate; spores hyaline or pale, ellipsoid, 4-celled and becoming muriform, 18 to 26 μ long and 8 to 12 μ wide.

Collected twice along the north shore of Lake Superior and in several places in the southwestern portion of the State. The material from the Lake Superior region has smaller, more erect lobes, more numerous apothecia, and narrower spores. However, it agrees well with some of Arnold's European material. On various rocks.



LEPTOGIUM TREMELLOIDES (L.) S. F. GRAY.

In the United States southward to Maryland and westward to Iowa. Also known in Canada. Found also in Europe and Africa.

7. *Collema pustulatum* Ach. Syn. Lich. 317. 1814.

Thallus suborbicular or irregular and scattered, small, scarcely exceeding 10 to 18 mm. in diameter in ours, the lobes becoming long and narrow and subdichotomously many-cleft or more irregularly divided, or even shorter and subentire, frequently ascending or suberect; more closely attached portions of the thallus usually dying and leaving the commonly ascending lobes separately attached to the substratum, thus giving the scattered appearance, the rhizoids few; in color, brownish olivaceous or darker, and scarcely lighter beneath; algal cells somewhat more numerous toward the surfaces, especially the upper in the closely adnate portions; apothecia small and appearing like pustules on the thallus-lobes, 0.2 to 0.7 mm. in diameter, immersed or adnate, the disk brown, reddish or darkening, flat or concave, frequently deeply sunken in the entire thalloid margin; hypothecium pale; hymenium pale below and brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores ovoid-ellipsoid, hyaline or pale, 4-celled and becoming muriform, 13 to 24 μ long and 10 to 13 μ wide.

Collected on calcareous rocks at Mankato.

Known from such rocks in Pennsylvania, Alabama, Illinois, and Iowa, and extending westward to the Pacific coast in British America. A strictly North American plant.

LEPTOGIUM Ach.; S. F. Gray, Nat. Arr. Brit. Pl. 1: 400. 1821.

PLATE 22.

The thallus is foliose and commonly orbicular, macroscopically appearing quite similar to that of *Collema*, but differing microscopically in that there is a cortex. This structure commonly consists of a single layer of cells, both above and below. The cortex makes the thallus somewhat more rigid than that of *Collema*, and renders the plants as a whole less gelatinous. In some of the species there is a rather poorly defined algal layer just below the upper cortex and somewhat of a medullary layer below this, but as a rule these layers can not be distinguished, though the algal chains are quite commonly more numerous toward the upper surface. These chains are hardly so long as in the last two genera. Rhizoids are rare, though clusters of simple ones may be found occasionally in any species at points where the thallus is closely attached. The thallus is partly attached by them, but for the most part simply adheres directly to the substratum. A single species, however, has numerous well-developed rhizoids, and this is sometimes separated from the genus.

The apothecia are quite common in some of the species, but seldom seen in others. The exciple is typically thalloid, but the algal cells may rarely disappear; or the exciple itself more rarely may be overgrown by the expanding disk and the whole structure of the apothecium become essentially biatoroid. The color of the disk is commonly some shade of brown, and it is usually flat or concave. The hypothecium, hymenium, and paraphyses are all much as in *Collema*. The spores of the species here admitted to the genus are pale and more or less muriform. Tuckerman admits plants having less highly developed spores, but his genus should doubtless be divided as it has been by some other authors.

The close relation of the present genus to *Collema* is apparent. The structure is somewhat higher in *Leptogium*.

Seven forms have been noted in the State. The habitats are similar to those of *Collemas*, but as a whole the plants are less confined to moist places.

Type species *Leptogium tremelloides* (L.) S. F. Gray, loc. cit.

EXPLANATION OF PLATE 22.—Fig. 1, a plant showing the thallus and the apothecia. Fig. 2, a portion of a thallus lobe with two apothecia. Fig. 3, a section of an apothecium and the thallus below; *a*, the hymenium, *b* and *c*, the hypothecium; *d*, the inner thallus with hyphae and algal cells; *e*, the lower cortex, thickened below the apothecium. Fig. 4, a section of the thallus; *a*, the upper cortex; *b*, the hyphae and algal cells; *c*, the lower cortex. Fig. 5, a paraphysis and an ascus. Fig. 6, free muriform spores. Fig. 7, algal filaments. Fig. 1, natural size; fig. 2, enlarged about 5 diameters; figs. 3, 4, enlarged 400 diameters; figs. 5, 6, 7, enlarged 650 diameters. From Schneider.

KEY TO THE SPECIES.

Rhizoids conspicuous.

- Lobes wide, rhizoids making a delicate nap..... 5. *L. myochroum*.
 Lobes narrower, rhizoids making a velvety nap..... 5a. *L. myochroum tomentosum*.

Rhizoids not noticeable except under the microscope.

Margins jagged and fringed.

- Lobes small and densely crowded, ascending and expanded toward the ends..... 1a. *L. lacerum pulvinatum*.

- Lobes as above except larger and less crowded..... 1. *L. lacerum*.

Margins undulate, lacerate, or isidioid, but not jagged and fringed.

- Upper surface not isidioid or lobulate; margins undulate, but neither isidioid nor lobulate..... 2. *L. pulchellum*.

Upper surface more or less isidioid granulate or lobulate.

- Thallus lead-colored above, frequently lighter below..... 3. *L. tremelloides*.
 Thallus dark lead-colored to greenish or olivaceous above, scarcely differing below..... 4. *L. chloromelum*.

1. *Leptogium lacerum* (Retz.) S. F. Gray, Nat. Arr. Brit. Pl. 1: 401. 1821.

Lichen lacer Retz. Fl. Scand. Prodr. 228. 1774.

Thallus closely adnate, more or less orbicular, middle-sized, 15 to 70 mm. in diameter, reticulately wrinkled, the many lobes ascending and obscuring the horizontal portions, expanded toward the ends, there sinuate and commonly divided into finely jagged and fringed margins, olivaceous-brown or more commonly lead-colored, scarcely lighter below, for the most part without rhizoids, the thallus adhering directly to the substratum; algal cells scattered throughout the thallus, but more numerous toward the top, so that algal and medullary layers are not distinctly differentiated; apothecia rather rare, small, 0.3 to 1.5 mm. in diameter, subsessile, the disk reddish brown and concave or flat, the margin thalloid, but the algal cells frequently disappearing, giving a biatoroid appearance, paler and entire; hypothecium pale; hymenium pale below and brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores pale, ellipsoid, muriformly many-celled, 27 to 48 μ long and 11 to 19 μ wide.

Generally distributed over the State. On rocks among mosses.

The plant is widely distributed in North America. Known also in South America, Europe, and Africa.

1a. *Leptogium lacerum pulvinatum* (Hoffm.) Nyl. Syn. Lich. 1: 122. 1858.

Collema pulvinatum Hoffm. Deutsch. Fl. 2: 104. 1795.

Thallus brownish, smaller, and composed of densely crowded and smaller lobes with finely fringed edges, giving the plant a more pulvinate appearance than usual. Even more seldom fruited than the species.

A single collection was made along the shores of Snowbank Lake. On humus, mosses, and dead pine leaves. Ours is finely fruited.

Tuckerman considered the North American plants to belong to the present subspecies or to *Leptogium lacerum lophaeum* (Ach.) Nyl.^a Possibly the last named subspecies, also a small form with long ciliate dissected lobes, may exist in the State.

Both subspecies are recognized in Europe and Africa.

2. *Leptogium pulchellum* (Ach.) Nyl. Syn. Lich. 1: 123. 1858.

Collema pulchellum Ach. Syn. Lich. 321. 1814.

Thallus suborbicular, middle-sized to large, 5 to 12.5 cm. in diameter, closely adnate, but the marginal lobes commonly free and more or less raised, as are frequently some of the more central ones also, the upper surface thrown into delicate plicate wrinkles, and the lower surface more or less pitted and similarly wrinkled, the lobes somewhat imbricated, rounded with entire or slightly undulate margins; commonly lead-colored above, lighter-colored beneath, for most part adhering directly to the substratum, the rhizoids few and, as in other species, only to be seen in sections; algal chains more numerous toward the top, but quite numerous toward the lower side also, the central portions having few algal cells and representing a more or less distinct medullary layer; apothecia small to middle-sized, frequently subpedicellate, 0.7 to 2 mm. in diameter, the exciple thalloid with usually entire margin, the disk commonly flat; hypothecium brownish; hymenium pale below and brownish above; paraphyses simple or rarely branched; asci clavate; spores pale, becoming more or less muriform, ellipsoid, 18 to 30 μ long and 9 to 16 μ wide.

Collected in widely separate portions of the State and no doubt generally distributed, though rare. On trees and once on rocks.

Doubtless generally distributed over North America, except in arctic regions; little known, however, in the West. A strictly American plant. Known also in South America.

3. *Leptogium tremelloides* (L.) S. F. Gray, Nat. Arr. Brit. Pl. 2: 400. 1821.

PLATE 22.

Lichen tremelloides L. f. Suppl. Pl. 450. 1781.

Thallus suborbicular, middle-sized, 30 to 75 mm. in diameter, rather less closely adnate than that of the last and somewhat thinner, the lobes more or less imbricated, smooth, of somewhat similar form, but smaller, with commonly more ascending and entire margins, but sometimes finely dentate or undulate, crisped and irregular; beset more or less with isidioid granules, which may pass into minute lobules, lead-colored, frequently somewhat lighter below; rhizoids very rare and only seen in sections; algal chains more numerous toward the upper surface, but a medullary region scarcely to be distinguished in the thin thallus; apothecia sessile or subpedicellate, somewhat smaller than in the last, 0.5 to 1.7 mm. in diameter, the disk brown and flat, or somewhat convex and sometimes overgrowing the entire or irregular thalloid margin; hypothecium commonly pale; hymenium pale throughout or brownish above; paraphyses simple or very rarely branched, frequently enlarged and brownish toward the apex; asci clavate; spores pale, ovoid-ellipsoid, becoming muriformly many-celled, 18 to 27 μ long and 8 to 12 μ wide.

Throughout the northern portion of the State, extending as far south as Taylors Falls. Commonly on rocks.

Throughout the portion of North America east of the western Cordilleras and also in Alaska. There are several subspecies, and one or more forms are known in all of the grand divisions.

4. *Leptogium chloromelum* (Sw.) Nyl. Syn. Lich. 1: 128. 1858.

Lichen chloromelos Sw. Fl. Ind. Occ. 3: 1892. 1806.

^aSyn. Lich. 1: 122. 1858.

Thallus thin, suborbicular or irregular and frequently more or less scattered, rather small, 25 to 60 mm. in diameter, or the scattered lobes extending over larger areas, becoming densely isidioid-granulate, the lobes more or less imbricate and ascending with crisped, undulate, or lacerate margins, or the margins produced into isidioid lobules, the marginal lobes, in the more continuous forms, somewhat more expanded; lead-colored, varying toward greenish or olivaceous, scarcely differing in color below; rhizoids and attachment of thallus as in the last; algal chains not so distinctly more numerous toward the top, and medullary and algal layers rather less distinct than in any of the above species; apothecia small in ours, 0.5 to 1 mm. in diameter, sessile, the disk brown and flat, the margin thalloid in structure, granulate, irregular, or more rarely entire; hypothecium pale; hymenium pale below and brownish above; paraphyses simple or rarely branched, frequently thickened and brownish toward the apex; asci clavate; spores ovoid to ellipsoid-pointed, pale, becoming muriformly many-celled, 15 to 32 μ long and 8 to 13 μ wide.

Collected at Taylors Falls and at Mankato. On sandstone. Perhaps most of ours should be referred to subspecies *conchatum* Tuck.^a

North American range scarcely differing from that of the last foregoing. Also quite as various in form as the last and known in some form in all of the grand divisions.

5. *Leptogium myochroum* (Schrad.) Tuck. Gen. Lich. 99. 1872.

Lichen myochrous Schrad. Journ. Bot. 1799¹: 18. 1799.

Thallus suborbicular, or irregular, somewhat closely attached to the substratum, small, and only slightly lobed or becoming larger and more lobed, 25 to 80 mm. in diameter, the lobes more or less ascending and imbricated, wide, rounded, subentire, undulate; lead-colored varying toward olivaceous or blackish, smooth or more or less rugose, somewhat granulate, clothed below with whitish rhizoids, composing a delicate nap; algal chains more numerous toward the top, a fairly well-developed medullary layer below, though containing scattered algal chains; apothecia middle-sized, 1 to 2 mm. in diameter, subsessile, the disk flat and reddish brown, the margin thalloid and more or less irregular and granulate; spores pale, ellipsoid, becoming somewhat muriform, 23 to 30 μ long and 7 to 9 μ wide.

Ours sterile, and the spore and apothecial characters taken from Tuckerman. Frequently excluded from the present genus.

Generally distributed over the State. On trees and rarely on rocks.

The plant is generally distributed over North America. Known also in Europe.

5a. *Leptogium myochroum tomentosum* (Hoffm.) Schaer. Lich. Helv. Spic. 534. 1842.

Collema tomentosum Hoffm. Deutsch. Fl. 2: 99. 1795.

Thinner, darker, usually narrower-lobed, more imbricated and having sinuate margins, velvety below.

The lobes tend to be normal in ours, however, and perhaps our plants should not be referred to the subspecies.

Collected on Carlton Peak and along the international boundary from Harding to Warroad. On trees.

Elsewhere in North America known only in the Rocky Mountains and Alaska. Known also in Europe

Family PYRENOPSISACEAE.

This family is a small one, represented in our flora by only two genera and a few species. The thallus is crustose or foliose, or may even exhibit a fruticose tendency as in the *Omphalarias*. A cellular cortex is present in *Pyrenopsis*, but not in *Omphal-*

^aSyn. N. A. Lich. 1: 163. 1881.

laria, which is quite gelatinous when wet. The algal symbiont is Gloeocapsa-like, and the gelatinous nature of the Omphalarias is due to the sheath of the cells or the colonies. There is an obscure differentiation into algal and medullary layers in the Omphalarias.

The apothecia are usually immersed and contain the simple or 2-celled spores, which are quite similar in the two genera and suggest a close relationship of their members, though these are quite different externally.

The family is somewhat closely related to the Collemaeae, and the relationship with the Pannariaceae is perhaps closer.

PYRENOPSIS Nyl. Mém. Soc. Sci. Nat. Cherb. 5: 143. 1857.

The thallus is crustose-conglomerate or with ascending coralloid branchlets. The whole structure is obscure and devoid of definite layers. However, in ours at least, a parenchymatous structure may be made out, which extends throughout, at least in the ascending branchlets. The algal symbiont consists of blue-green cells, occurring in clusters, varying considerably in size and number in a cluster and the individual cells not differing greatly from those of Omphalaria. The plants are obscure, and when conspicuous enough to attract notice, they may easily be overlooked as so much dirt on the rocks, or if noted as lichens, passed over as some one of the darker and more obscure Pannarias. The apothecia in ours are usually quite open-discoid, and yet they are rather rare, adnate or immersed, small and very difficult to distinguish when present. A thalloid exciple is present. The hymenium and the hypothecium are both more or less brownish. The paraphyses are usually simple and rather slender, but not seldom more or less gelatinized and indistinct. The spores are almost constantly simple.

Nylander recognizes *Synalissa* Fr.^a as a separate genus, somewhat below the present one in that the thallus is scarcely cellular and the apothecia are more inclined to be immersed. He admits to his lower genus, however, at least one form having a cellular thallus. Tuckerman admits all these species to the present genus and also certain species having the algal cells in chains. Much work will be required before the questions involved can be settled, but our three species may certainly be placed in a single genus. Again, while there is yet much doubt regarding the relationship of some of the species usually assigned to the present genus and *Synalissa*, it appears to be certain enough that ours are more closely related to *Pannaria* than to *Collema*, and are yet nearer to *Omphalaria*.

Three species occur in the State. On rocks.

Type species *Pyrenopsis fuscicula* Nyl. loc. cit.

KEY TO THE SPECIES.

Thallus olivaceous, granulose; spores 8 to 11 μ long and 5 to 6 μ wide..... 1. *P. melambola*.

Thallus blackish, granulose.

Spores 10 to 20 μ long and 7 to 9 μ wide, sometimes 2-celled. 2. *P. phaeococca*.

Spores 12 to 13 μ long and 6 to 8 μ wide..... 3. *P. polycocca*.

1. *Pyrenopsis melambola* Tuck. Syn. N. A. Lich. 1: 136. 1882.

Synalissa melambola Tuck. Proc. Amer. Acad. 12: 170. 1877.

Thallus of minute olivaceous granules, compacted into finally thick and substipitate scabrous, black areoles, these reaching 1 mm. in diameter and forming a close crust; apothecia minute, 0.2 to 0.4 mm. in diameter, 1 to 6 in each areole, immersed, the disk black, the margin thalloid, persistent, and of the same color as the disk; hypothecium pale brownish; hymenium usually pale below and pale brownish

above; paraphyses gelatinized and indistinct; asci clavate; spores simple, ellipsoid, 8 to 11 μ long and 5 to 6 μ wide, thus somewhat larger than according to Tuckerman's measurements, as are also the apothecia.

A single collection was made on a bowlder at Mankato in 1899. Forms of *Pyrenopsis* have been noted frequently in various portions of the State, but in the absence of fruit it has been impossible, except in this instance and the ones below, to refer the specimens to species with any degree of certainty.

A North American plant, previously only known in the original locality in Alabama.

2. *Pyrenopsis phaeococca* Tuck. Syn. N. A. Lich. 1: 136. 1882.

Synalissa phaeococca Tuck. Gen. Lich. 80. 1872.

Thallus of blackish, scarcely coralloid granules, which form an areolate crust; the areoles of about the same size as those of the last, rarely reaching 1 mm. in diameter; apothecia somewhat larger than in the last, 0.2 to 0.5 mm. in diameter, adnate or immersed, 1 to 3 in each areole, the disk evident and concave in ours, black with a margin of the same color, hypothecium pale brown; hymenium pale below and brownish above; paraphyses simple, frequently thickened and brownish toward the apex; asci clavate; spores simple or rarely 2-celled, ovoid-ellipsoid, 10 to 20 μ long and 7 to 9 μ wide. The algal cells are few in each cluster, and in this and other points, as the color, the plant seems quite as near the next, though the spores agree better here.

A collection was made at Mankato in 1899 and another at Grand Marais in 1902. On bowlders.

A North American lichen, previously known in North Carolina, Massachusetts, and New Hampshire. The other plant which our specimen resembles, is also confined to our grand division, having been collected in Vermont.

3. *Pyrenopsis polycocca* (Nyl.) Tuck. Syn. N. A. Lich. 1: 136. 1882. PLATE 23, A.

Synalissa polycocca Nyl. Syn. Lich. 1: 96. 1858.

Thallus of blackish granules, which pass into a more or less areolate crust, the areoles of the same size as those of the last or smaller and for the most part absent when the thallus is continuously granulose; apothecia rather numerous, sometimes a dozen or more in a single areole and almost completely obscuring the thallus, minute, 0.1 to 0.3 mm. in diameter, of the same color as the thallus, globose, with a punctiform or slightly open and urceolate disk; hypothecium pale or pale brownish; hymenium pale below and brownish above; paraphyses more or less coherent and indistinct; asci cylindrico-clavate; spores ellipsoid, simple, 12 to 13 μ long and 6 to 8 μ wide.

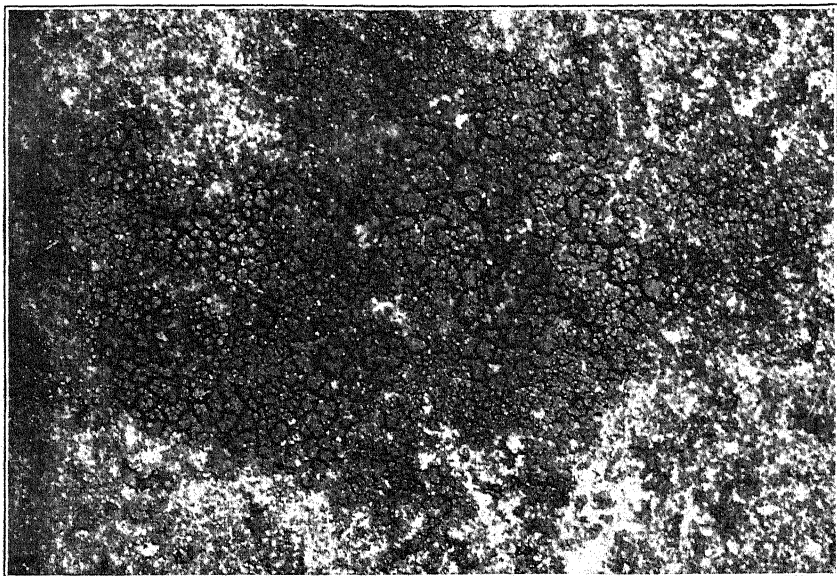
Collected on rocks along the shore of Lake Superior at Grand Marais.

A North American plant, previously reported from Vermont.

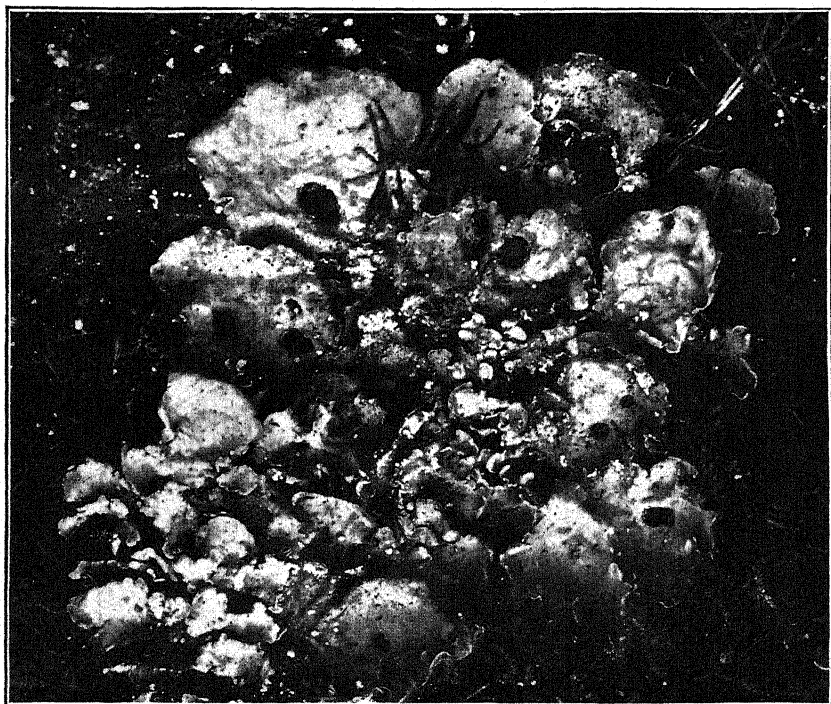
EXPLANATION OF PLATE 23.—A, Plant of *Pyrenopsis polycocca* on rocks, showing the granulate and somewhat areolate thallus. B, Plant of *Solorina saccata* on rocks, showing the foliose thallus and the immersed apothecia. A enlarged about 3 diameters; B, about $\frac{2}{3}$ diameters.

OMPHALARIA Dun. & Gir. in Dur. Fl. Algér. 1: 200. pl. 18. f. 4, 5. 1846.

The thallus is neither strictly fruticose nor yet in most instances foliose. It is commonly small and somewhat raised from the substratum, exhibiting thus at least a fruticose tendency, and is attached to the substratum at a single point. There is no cellular cortex, but there is an outer gelatinous layer composed of gelatinized hyphæ and walls of dead algal cells. Within or below this is an algal layer, consisting of the algal cells and hyphal branches. The central portions of the thallus, or in the more foliose forms the lower part, is frequently differentiated as a more or less distinct medullary layer. The algal cells, in all of ours at least, occur in groups, these varying considerably in number of cells in each, and each cell of a group having its own wall. Yet, in any of the species, the cells may sometimes occur singly. On the



A. *PYRENOPSIS POLYCOCCA* (NYL.) TUCK.



B. *SOLORINA SACCATA* (L.) ACH.



whole, these algal symbionts seem to be a form of *Gloeocapsa*. In some species found in North America and referred to the present genus the algal cells occur in chains. These we have not studied carefully, but they should perhaps be referred to another genus. The thallus as a whole may be merely an irregular or even somewhat rounded mass, or it may be somewhat or even decidedly branched. The color is usually a dull black, and the thallus reminds one somewhat of that of certain *Collemas*.

The apothecia are very small, subglobose and immersed, or more rarely becoming superficial and more or less disk-shaped. They are either terminal on the lobes or variously scattered over the thallus. The hypothecium and the hymenium vary from colorless to brown. The paraphyses are more or less coherent and indistinct, but seem to be uniformly simple. In the material examined, the asci scarcely showed apical thickening. In the species admitted here, the spores are hyaline and are simple, though plants having 2-celled spores have usually been admitted to the genus.

Notwithstanding the peculiarity of the present genus as regards the algal symbiont, it shows an apparently close relationship with *Senecoblastus* and a somewhat more remote one, when the spores are considered, with *Collema*. Yet, doubtless, all considered, the relationship is closer with *Pyrenopsis* or *Lichnia*.

Three species have been determined from the rocks of the State. Other sterile forms have been collected.

Type species *Omphalaria nummularia* (Duf.) Dur. & Mont. loc. cit.

KEY TO THE SPECIES.

- Thallus scarcely or only slightly lobed; plants small 1. *O. minnesotensis*.
 Thallus plainly lobed; plants larger.
 Lobes strongly ascendant 2. *O. pulvinata*.
 Lobes shorter and only slightly raised 3. *O. phyllisca*.

1. *Omphalaria minnesotensis* sp. nov.

Thallus adnate or somewhat raised from the substratum, irregular in form or rarely rounded, very small, 0.5 to 2 mm. in diameter, above smooth or more commonly uneven; lobes absent or short and irregular, black and rigid; algal cells in clusters; apothecia immersed and minute, scarcely exceeding 0.3 to 0.5 mm. in diameter, globose with a punctiform disk, often in plainly raised pustules, one to several in each plant; hypothecium pale or slightly colored; hymenium pale; paraphyses more or less coherent, gelatinous and indistinct; asci cylindrico-clavate and variously irregular; spores minute and numerous in each ascus, subspherical to ellipsoid, 3 to 6 μ long and 2 to 3 μ wide.

On calcareous rocks at Minneapolis.

2. *Omphalaria pulvinata* (Schaer.) Nyl. Ach. Soc. Linn. Bord. 21: 265. 1856.

Collema stygium pulvinatum Schaer. Enum. Lich. Eur. 260. 1850.

Thallus pulvinately lobed, the lobes ascendant or suberect, giving the thallus a fruticose tendency, but also with a basal horizontal and strictly foliose portion, predominating in younger and less developed states and giving character to the whole structure; black in color, the lobes more or less divided and having variously irregular margins; apothecia minute, scarcely exceeding 0.6 mm. in diameter, sometimes becoming prominent and tuberculate, said to be pallescent (Nylander), though this has not been observed in ours, more commonly along the margins of the lobes; hypothecium pale or pale brownish; hymenium pale below and pale brownish above; paraphyses simple, more or less gelatinized and coherent; asci clavate; spores short-ellipsoid, 9 to 12 μ long and 5 to 7 μ wide.

Collected once in the State. On calcareous rocks at Mankato.

Previously known from New England, New York, Iowa, Nebraska, and Colorado. But Tuckerman seems not to have seen the apothecia, which are common enough in ours and in the Iowa plant. Known also in Europe and Africa.

3. *Omphalaria phyllisca* (Wahl.) Tuck. Gen. Lich. 84. 1872.

Endocarpon phylliscum Wahl. in Ach. Meth. Lich. Suppl. 25. 1803.

Thallus strictly foliose, or sometimes showing a slightly fruticose tendency, only slightly raised from the substratum and presenting above a lobulate, rosulate, flattened surface with the marginal lobes better developed, rarely somewhat imbricated, black and rigid, small, 1.5 to 3 mm. in diameter in ours, scarcely so gelatinous as the other two species; algal cells unusually large and frequently solitary, 10 to 28 μ in diameter; apothecia minute, scarcely exceeding 0.5 mm. in diameter, immersed-globose with a punctiform disk, the whole structure appearing as minute slightly raised pustules scattered over the upper surface of the thallus; hypothecium pale or pale brownish; hymenium pale; paraphyses simple, but becoming gelatinized and indistinct; asci cylindrical to fusiform; spores shortly oblong-ellipsoid, 6 to 10 μ long and 4 to 5 μ wide, 8 to 16 in each ascus.

A single collection was made at Grand Marais. On the face of a perpendicular bluff near the shore of Lake Superior.

Previously collected in North America in New England, Oregon, and along the north shore of Lake Superior in Canada. Known also in Europe.

The plant reported as this species from Redwood Falls is not the same, and a plant similar to the latter was collected at Grand Portage. The spore characters of these two plants were not shown distinctly in the final examination, and they can not be definitely located for the present. Our plants also resemble strongly *Omphalaria pyrenoides* Tuck. from New Mexico.

Family EPHEBACEAE.

The family is represented in our flora by a single genus with one or two species. So far as these two species with the same algal symbiont, *Sirosiphon*, are concerned, the family is perfectly distinct. But there are a number of other forms with different algal symbionts which are frequently placed near *Ephebe*, and which might, if considered, invalidate the distinct definition of the family. One of these is *Lichnia*, a rare North American lichen genus, and another is what we have placed in the next family under the name *Pannaria nigra*.

The whole form of the plants is determined by the algal symbiont^a in our representatives of the family, this alga having a fruticose habit. The other characteristics of thallus and apothecia are sufficiently discussed under the single genus below.

The relationship of the present family with the *Pannariaceae* is apparent, especially through *Pannaria nigra*. The relationship is hardly to be regarded as a close one, however, when we consider that even in this species of *Pannaria* there is parenchymatous tissue throughout and the form of the thallus is determined by the fungal symbiont.

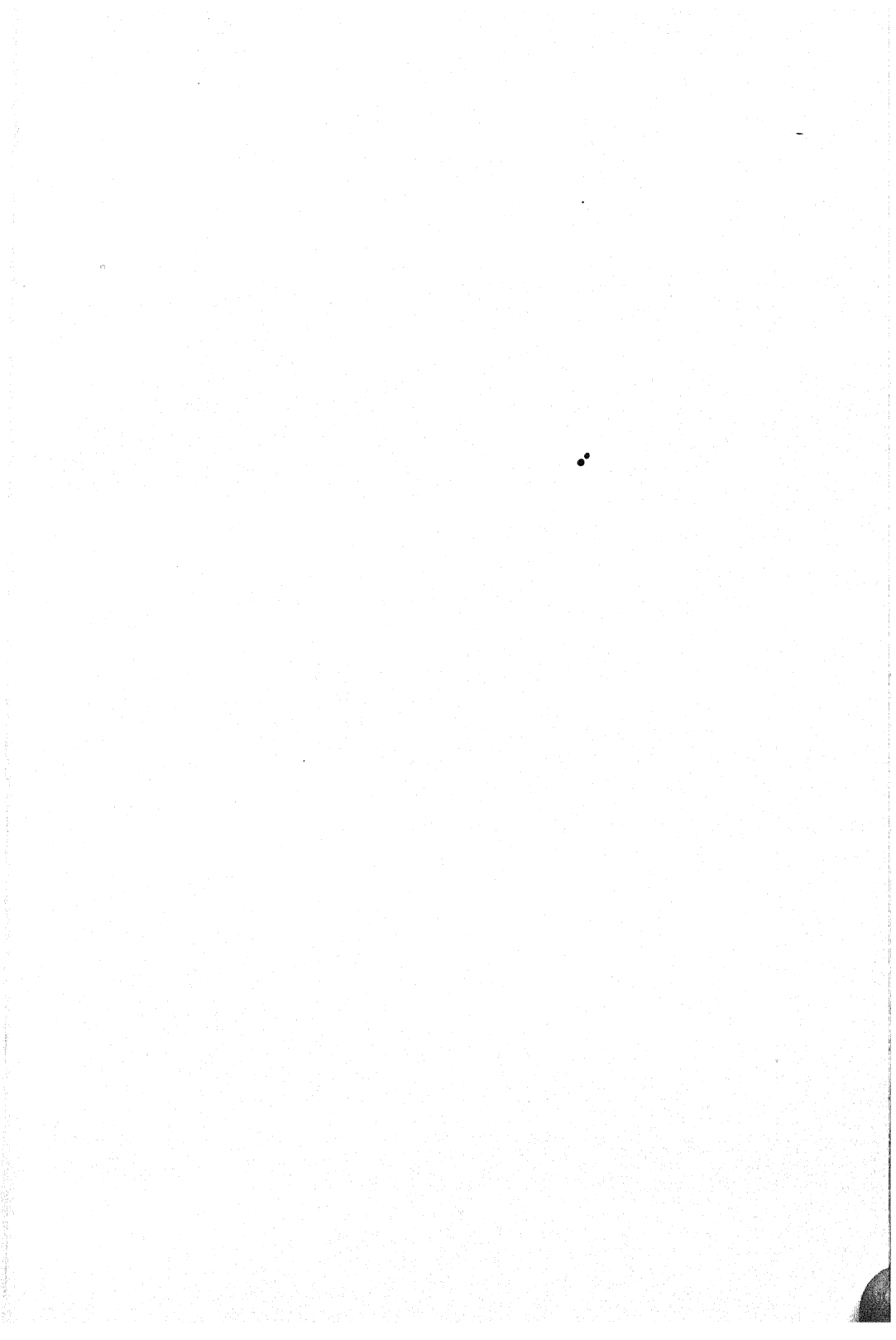
The *Ephebaceae* are lower than the *Pannariaceae*, both as to thallus structure and as to apothecial and spore characters, but the present family scarcely stands between the last two families and the *Pannariaceae*.

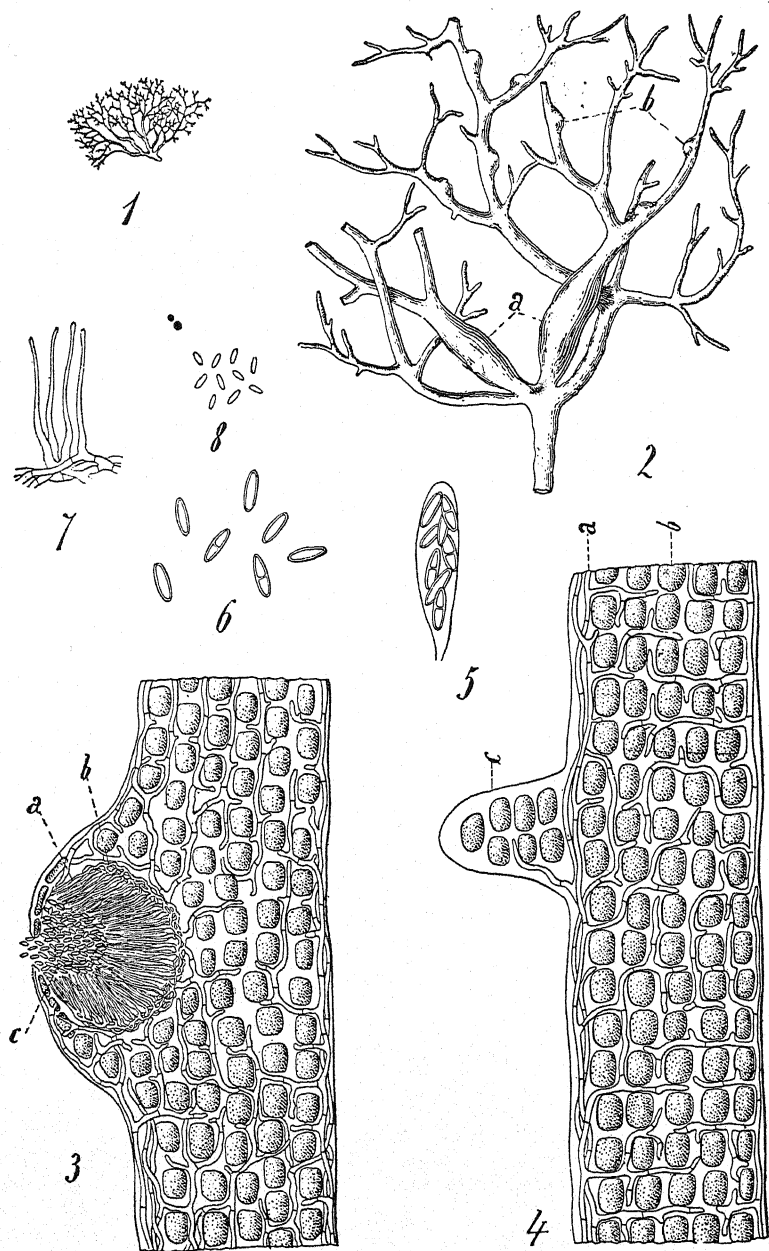
EPHEBE Fr. Syst. Orb. Veg. 1: 256. 1825.

PLATE 24.

The thallus is peculiar in structure and wholly different from that of any other Minnesota lichen genus. The form is entirely determined by the algal symbiont,^a which is the blue-green filamentous alga *Sirosiphon*. This gives us a brownish or blackish branched fruticose thallus of small size and not differing macroscopically from the free alga, which grows on the same moist rocks as the lichen. Hence every specimen must be carefully studied microscopically to ascertain whether the lich-

^a See footnote, p. 23.





EPHEBE PUBESCENS (L.) FR.

enoid symbiotic condition exists or not. If the fungal hyphae are present, they are found to extend in a longitudinal direction between the algal cells or just beneath the outer algal sheath. As has been observed by Schwendener, in some of our specimens there is a parenchymatous cellular structure toward the basal older portions of some of the thalli. This is not a cortex, but extends throughout the whole diameter of the filament. In these same filaments the hyphal threads may usually be detected toward the ends of the filaments. The hyphae may be few or many, and enlargements often occur here and there on the thalli from which hyphae protrude in dense clusters. These enlargements may give rise to apothecia or the so-called spermagonia, but we have been unable thus far to detect any such structures in any specimens examined. Possibly certain structures examined were old spermagonia that had discharged their spermatia.

The apothecia are minute, immersed in the thallus, or becoming superficial and globose-discoid. The spores are hyaline, oblong or ellipsoid, simple or 2-celled. As indicated above, none have yet been found in any of our specimens.

Of our lichens the present genus is evidently most closely related to *Pannaria*, though here the relation scarcely seems to be a very close one. *Pannaria nigra* appears somewhat similar under a hand lens, though not so microscopically. Probably *Lichnia*, thus far not noted in Minnesota, is more closely related.

Two species have been reported from the State, but one of these, in the absence of fruit in the specimen, must be regarded as doubtful. The plants occur on rocks.

Type species *Lichen pubescens* L. Sp. Pl. 1155. 1753. (*Ephebe pubescens* (L.) Fr.)

EXPLANATION OF PLATE 24.—Fig. 1, the plant. Fig. 2, *a*, position of apothecia; *b*, spermagonia. Fig. 3, a section of a branch and a spermagonium; *a*, sterigmata; *b*, the inclosing hyphae; *c*, the spermatia. Fig. 4, a section of the thallus; *a*, fungal hyphae; *b*, algal cells; *c*, a young branch. Fig. 5, an ascus. Fig. 6, free spores. Fig. 7, sterigmata. Fig. 8, spermatia. Fig. 1, natural size; fig. 2, enlarged about 4 diameters; figs. 3, 4, 7, enlarged 400 diameters; figs. 5, 6, 8, enlarged 650 diameters. From Schneider, except 5 and 6, which are from Crombie.

***Ephebe pubescens* (L.) Fr. in Nyl. Syn. Lich. 1: 90. 1858.**

PLATES 20, B, 24.

Lichen pubescens L. Sp. Pl. 1153. 1853.

Thallus much branched, rather rigid, the branching subdichotomous, the branches subcylindrical, somewhat spreading and variously tangled; usually blackish brown but sometimes olivaceous, the whole plant 3 to 25 or possibly sometimes 30 mm. in length, the filaments sometimes reaching 0.75 to 1 mm. in diameter toward the rarely parenchymatous basal portions; apothecia immersed several together in swellings of the thallus, the disk punctiform; spores simple or 2-celled, oblong-ellipsoid, 11 to 16 μ long and 3 to 4 μ wide.

Frequent in the northern portion of the State, and once found as far south as New Ulm. On rocks and, if on horizontal ones, preferring depressions in which water stands after rains. Ours sterile and perhaps nearer *Ephebe solida* Born.^a

Throughout the eastern region bordering the Appalachian system of mountains and northward to Greenland. Also reported from Vancouver Island. Known also in Europe and northern Africa.

The material recorded in the preliminary reports as *Ephebe solida* seems nearer *E. mammosum* (Lyngb.) Fr., but is sterile and too uncertain to record.

EXPLANATION OF PLATE 20.—See p. 135.

Family PANNARIACEAE.

The family as represented in our flora contains three genera, in which the thallus is certainly higher than in any of the closely related families immediately preceding, and at the same time quite different in external appearance from the forms of thalli in the two closely related families next following. However, there is no escape

from some uncertainty in any limitations that may be set to families in these closely related lichens, and Schneider includes the last family, the present one, and the next two all in the Pannariaceae.

Except for the Omphalarias, the lichens of the last three families have shown no differentiation into algal and medullary layers, and we prefer to exclude from the present family Ephebe with its rudimentary thallus. Likewise it seems at least conducive to clearness to separate the three genera of the present family from the much larger and more plainly foliose, lobed, and otherwise different thalli of the members of the next two families.

The algal symbiont is always a blue-green alga, most commonly *Polycoccus*. The thallus is small, but foliose or foliose-squamulose, and upper and lower cortices are always present. The apothecia are immersed or superficial. The spores vary from simple and minute in the first genus to 4-celled in some of the species admitted to the last genus. Thus as regards spore characters, the present family is hardly so high as the *Collembaceae*, but the spores of lichens are in all probability often degenerate, and greater spore degeneration may be expected frequently in forms otherwise higher.

ENDOCARPISCUM Nyl. Flora 47: 487. 1864.

The thallus is plainly foliose and usually not so closely attached to the substratum as that of *Heppia*. Indeed, the whole external appearance of the thallus is quite like that of *Dermatocarpon*, and one would very naturally pass over either of our species as members of that genus; for the fact of the apothecia being commonly immersed points toward *Dermatocarpon* quite as much as does the general appearance. There is a good cortex on both sides, but the development is on the whole better on the lower side. The medullary layer is commonly well developed, though scarcely so in one of the species here admitted to the genus. The algal layer is also well represented, the algae extending well upward into the upper cellular area and obscuring the cellular structure. The algal cells are blue-green, but scarcely more than half as large as those of *Heppia*, with which genus the present one is frequently placed.

The apothecia are commonly sunken into the thallus and usually indicated by an ostiole, though they may even become superficial and disk-like and have a thalloid exciple. The spores are simple, hyaline, minute, and numerous in the asci.

The superficial resemblance of the present genus to *Dermatocarpon* has already been noted, and the species are sometimes included in that genus. However, the propriety of including in a single genus forms having very different algal symbionts is uncertain. On the other hand, there seems to be a somewhat close resemblance between *Endocarpiscum* and *Heppia*, though as regards the algal symbiont the relation is rather with *Sticta* or *Pannaria*.

Two species have been noted for the State, the second of which we place in the present genus because of spore resemblance and apparent similarity of algal symbionts. Also as to thallus-structure this species is quite as much at home here as in the genus *Heppia*. On rocks or earth.

Type species *Endocarpiscum guepinii* (Moug.) Nyl. loc. cit.

KEY TO THE SPECIES.

- On rocks, thallus of moderate size and thickness..... 1. *E. guepinii*.
On earth, thallus smaller and thinner..... 2. *E. polysporum*.

1. *Endocarpiscum guepinii* (Del.) Nyl. Flora 47: 487. 1864.

Endocarpon guepinii Del.; DC. Bot. Gal. ed. 2. 2: 594. 1830.

Thallus foliose, thickened, commonly raised from the substratum toward the margins; ours rather thicker than foreign specimens at hand and not showing the sorediate border common in other material; greenish or brownish olive, flat or in ours commonly variously irregular above, below smooth or wrinkled and usually

lighter in color, attached to the substratum at a single point, the medullary layer well represented; small, 2.5 to 6 mm. in diameter; apothecia deeply sunken in minute pits, or becoming superficial and disk-shaped; spores rounded or oblong.

No mature fruit has been found, and the spore and apothecial characters taken from Tuckerman.

Collected on frequently wet rocks, at Morton, and reported as an *Endocarpon*.

Elsewhere in North America from Massachusetts, Maryland, Arkansas, and California. Known also in Europe and Australia.

2. *Endocarpscium polysporum* (Tuck.) Fink.

Heppia polyspora Tuck. Syn. N. A. Lich. 1: 115. 1882.

Thallus foliose and closely attached to the substratum by means of numerous rhizoids, flat above or depressed with a raised margin, orbicular or irregular in form, small or very small, 1.5 to 4.5 mm. in diameter, smooth, olive-green or olivaceous, usually darker at the margin and below, the medullary layer represented by loosely arranged irregular cells, forming a tissue resembling the spongy parenchyma of leaves; apothecia immersed in the thallus, without thalloid exciple, the disk somewhat depressed and dark brown or black, very small, 0.2 to 0.5 mm. in diameter; hypothecium pale yellowish brown; hymenium pale below and yellowish brown above; paraphyses very slender, commonly simple, frequently enlarged and brownish toward the apex; asci cylindrical, varying toward clavate or ellipsoid; spores subspherical, 4 to 7 μ the longest way.

A few apothecia are larger, and the spores are also somewhat larger than Tuckerman's plant showed. Possibly the plant should be separated from the present genus, but it can scarcely be placed with *Heppia* as was attempted by Tuckerman.

Collected on earth at Granite Falls.

Tuckerman's plant was from Colorado. Nylander's *Heppia arenivaga* from Japan^a appears to be the same plant.

Heppia polyspora of the preliminary reports.

HEPPIA Naeg. in Hepp. Spor. Flecht. Eur. pl. 7. f. 49. 1853.

The thallus is distinctly foliose and closely attached to the substratum by means of rhizoids, though often rising more or less at the margins. The structure is peculiar in that the thallus is cellular throughout. The cells of three or more layers above are elongated horizontally and correspond to the usual upper cortex. Below this the cells are rather loosely arranged and elongated vertically, those midway between the upper and lower surfaces being most elongated and replacing a medullary layer. The cells of the lower portion are again less elongated and correspond somewhat to a lower cortex. The algal cells are scattered throughout the whole region of vertically elongated cells and even extend into the cortical regions. The algae are blue-green, but larger than those of *Solorina* and *Pannaria*. The cells are said to occur in chains, but this is difficult to make out. They are usually large, 14 to 22 mm. long.

The apothecia are commonly immersed in the thallus, though in *Heppia despreauxii* they may be more or less raised. Tuckerman seems to have distinguished a thalloid exciple in certain raised apothecia of the above species, but such a structure is commonly absent. The hypothecium and hymenium are pale or slightly colored. The paraphyses are commonly simple and somewhat coherent. The spores are simple.

The resemblance of the present genus to *Solorina* in upper surface and disposition of apothecia, is not difficult of detection, but in the minute anatomy of the thallus we encounter very radical differences. The relation as to thallus is probably nearer to *Endocarpscium*, though the algal cells are quite different.

A single species occurs in the State. On calcareous soil.

Type species *Heppia urceolata* Naeg. loc. cit.

^a Nyl. Lich. Jap. 104. 1890.

1. *Heppia despreauxii* (Mont.) Tuck. Gen. Lich. 46. 1872.

Solorina despreauxii Mont. in Webb & Berth. Hist. Nat. Canar. 3²: 104. 1840.

Thallus foliose or possibly to be considered squamulose, closely attached to the substratum by numerous rhizoids, orbicular with the edges sometimes raised and crenately lobed, very small, 1.5 to 4 mm. or possibly reaching 6 mm. in diameter, or frequently the thalli clustered into a continuous crust covering an area 20 to 30 mm. in diameter, smooth above or frequently somewhat rugulose, olive in color, varying toward green or black, usually pale below; apothecia frequently solitary in the small thalli, commonly immersed and depressed-urceolate, rarely even convex; the disk reddish brown, small or becoming larger and occupying nearly the whole thallus, 0.75 to 2.5 mm. in diameter; hypothecium pale to pale yellowish; hymenium pale below and yellowish above; paraphyses somewhat coherent, commonly simple, frequently thickened and brownish toward the apex; asci clavate to cylindrical; spores hyaline, oblong-ellipsoid, 17 to 26 μ long and 7 to 10 μ wide.

Collected on calcareous soil in widely separated portions of the State. No doubt occurring wherever such soil exists in Minnesota.

Widely distributed in the United States, but I do not find it recorded from British America. *Heppia virescens* (Despr.) Nyl., reported for North America, is the same, and probably also *Heppia terrena* Nyl. from California. Known also in Europe and Africa.

PANNARIA Del. in Bory, Dict. Class. Hist. Nat. 13: 20. 1828.

The thallus may be distinctly foliose, though more often small and squamulose. It is usually quite closely attached to the substratum by means of rhizoids, though often resting upon a more or less distinct hypothallus. Indeed, it is in the present genus that the so-called hypothallus finds its best expression. The thallus appears to be crustose in some species, but so far as we have examined there is more or less of a cellular cortex below as well as above. This is true of the Minnesota species at least. The upper cortex is well developed, thick, the cells large and distinct. The medullary and algal layers are distinct in the more strictly foliose forms, but in those approaching a squamulose condition there appears to be a parenchymatous structure throughout and algal cells scattered throughout, except in the outer cells of the cortex. In all of ours, the algal symbiont is a blue-green alga, probably *Polycoccus*, and the chains of cells can usually be seen readily enough. In color the thallus varies from sea-green to a dull black.

The apothecia are usually small and sessile or subsessile upon the thallus. The thalloid margin may be present or absent, sometimes even in a given species. The disk is usually more or less concave and varies in color from a reddish brown to a dull black. The hypothecium and the hymenium vary from pale to brown. The asci vary from clavate to cylindrical in form, and the pale or hyaline spores from simple to 4-celled.

Tuckerman has included in the genus forms having green algal cells, others having both green and blue-green, and others having blue-green only. Doubtless his genus *Pannaria* should be divided into at least four genera. However, excluding *Amphiloma*, all of our Minnesota species are forms having the blue-green algal cells. There is still a difficulty as to spore characters, but simple and 2-celled spores occur in one species and 2 and 4-celled spores in two others, so that a division on this basis alone would be somewhat arbitrary. On the other hand, the last three species present certain differences in thallus structure, and we may be committing a serious error in not recognizing the genus *Lecothecium* of Trevisan.

The genus is related somewhat closely to *Collema* and less closely to *Heppia* and *Peltigera*.

Seven forms occur in Minnesota. On trees, rocks, or earth.

Type species *Pannaria rubiginosa* (Thunb.) Del. loc. cit.

KEY TO THE SPECIES.

On wood.

- Thallus plainly foliose, not sorediate or isidioid..... 1. *P. rubiginosa*.
Thallus plainly foliose, sorediate or isidioid..... 1a. *P. rubiginosa*
conoplea.

Not confined to wood.

On rocks or wood.

- | | |
|---|----------------------------|
| Squamulose instead of plainly foliose; spores 16 to 22 μ long. | 2. <i>P. leucosticta</i> . |
| Squamulose instead of plainly foliose; spores 20 to 28 μ long. | 4. <i>P. lepidiota</i> . |

On rocks always.

On calcareous rocks or pebbles.

- | | |
|---------------------------------------|-------------------------|
| Blue black hypothallus prominent..... | 6. <i>P. nigra</i> . |
| Blue black hypothallus absent..... | 5. <i>P. petersii</i> . |

On rocks other than calcareous; thallus of small squam-
ules..... 3. *P. microphylla*.

1. *Pannaria rubiginosa* (Thunb.) Del. in Bory, Dict. Class. Hist. Nat. 13: 20. 1828-1831.

Lichen rubiginosus Thunb. Prodr. Fl. Cap. 176. 1794.

Thallus plainly foliose, usually orbicular, middle-sized or larger, 20 to 65 mm. in diameter, closely attached to the substratum, rather smooth above, plainly lobed, the lobes quite long and sinuate or divided toward the more or less raised and crenate ends, usually more or less imbricated, sea-green or varying toward ashy, yellowish or lead-color, below lighter in color and clothed with conspicuous rhizoids of the same color, though the whole lower surface, especially toward the margin, is obscured and darkened by the more or less conspicuous blue black hypothallus; lower cortex absent in some spots and very poorly developed at best; apothecia small, 0.5 to 2.5 mm. in diameter, sessile, the disk brown, the thalloid margin crenulate; hypothecium more or less brownish; hymenium colorless below and brownish above; asci clavate; paraphyses simple or rarely branched, the apex commonly enlarged and brownish; spores simple, colorless, ellipsoid-pointed, 14 to 24 μ long and 6 to 10 μ wide.

Thus far reported only along the international boundary, from Kettle Falls westward. However, the relation of the present plant, and the subspecies below, to *Pannaria lepidiota* is a close one. On cedars in swamps.

The plant is widely distributed in North America. It is also known in all the grand divisions.

- 1a. *Pannaria rubiginosa conoplea* (Ach.) Nyl. Syn. Lich. 2: 30. 1860.

Parmelia conoplea Ach. Lich. Univ. 467. 1810.

Thallus grayish-sorediate or isidioid, passing toward the center into a continuous crust; apothecia with algal cells of thalloid exciple wanting, or even strictly biatoroid.

Along the western part of the international boundary from Beaudette to Harding. Also collected at Tower. On cedars in swamps.

Known in North America from New England northward into British America and also in California. Also known in South America and Europe.

2. *Pannaria leucosticta* Tuck. Proc. Amer. Acad. 4: 404. 1860. PLATE 25.

Thallus squamulose and scarcely approaching a foliose condition, the squamules resting upon a thin, blackish hypothallus, closely adnate or the margins raised, those of the circumference more expanded and elongated, crenate or pinnately lobed, those of the center smaller, more imbricated and ascendant with entire or dentate-crenate margins, these more frequently white-powdery; squamules 0.5 to 1 mm. wide

and 1 to 2 mm. long; color varying from ashy to brown, ours frequently light below where not darkened by the hypothallus; lower cortex absent or very poorly developed; apothecia adnate, the disk reddish brown and frequently convex, the thalloid margin crenate, frequently white-powdery and often disappearing, small, scarcely reaching 1 mm. in diameter in specimens seen; hypothecium pale or slightly brownish; hymenium pale below and brownish toward the top; asci clavate; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; spores simple, hyaline, ellipsoid to ellipsoid-pointed, 16 to 22 μ long and 8 to 12 μ wide.

Generally distributed along the western international boundary as far east as Harding. On cedars in swamps and rarely on rocks.

Generally distributed throughout North America east of the Rocky Mountains. Found also in Africa.

EXPLANATION OF PLATE 25.—Plant on white cedar, showing the apothecia and the squamulose thallus. Enlarged $1\frac{1}{2}$ diameters.

3. *Pannaria microphylla* (Sw.) Mass. Ric. Lich. 112. f. 221. 1852.

Lichen microphyllus Sw. Vet. Akad. Handl. 301. 1791.

Thallus squamulose, closely adnate or the margins somewhat raised, the squamules more or less imbricated, rather thick, expanded or collected into a continuous crust, the margins sometimes rather obscurely crenate, smaller than those of the last above; sea-green varying to ashy or tawny-brownish, usually dark below, though the hypothallus is obscure or absent; lower cortex wanting or poorly developed; apothecia adnate, the disk pale brown or blackening, frequently convex, the thalloid margin crenate and often disappearing so that the apothecia become biatoroid, small, 0.5 to 1 mm. in diameter; hypothecium pale; hymenium colorless below and brownish above; asci clavate; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; spores hyaline, simple, ellipsoid, 14 to 19 μ long and 5 to 7 μ wide.

Collected in several widely separate localities and doubtless generally distributed over the State. On all rocks except lime.

The plant is widely distributed in North America. Known in all the grand divisions except Australia.

4. *Pannaria lepidiota* (Sommerf.) Th. Fr. Nov. Act. Soc. Sci. Ups. III. 3: 174. 1861.

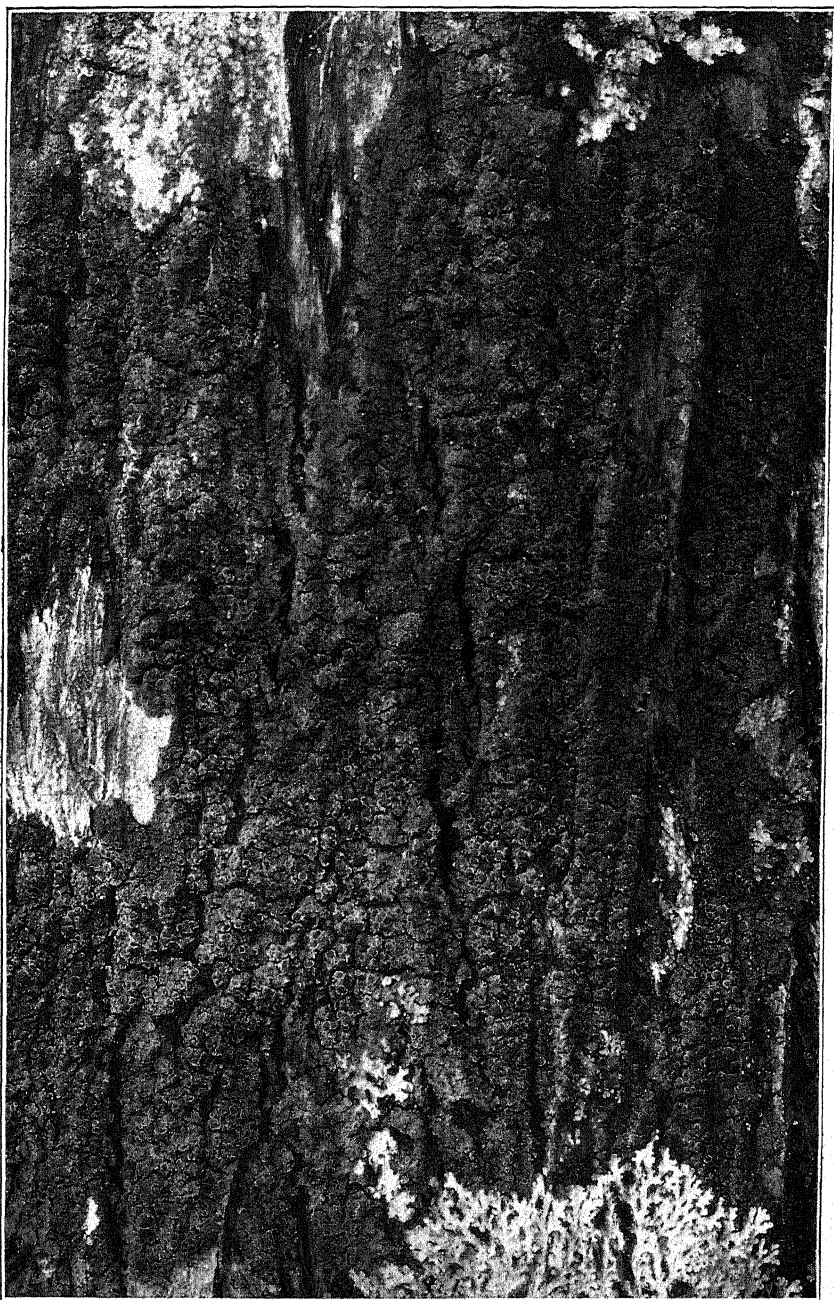
Lecidea carnosa lepidiota Sommerf. Suppl. Fl. Lapp. 174. 1826.

Thallus squamulose, the squamules larger than in the last, somewhat crenately lobed, the margins often warty and gray-sorediate, the marginal lobes more expanded and elongated and more deeply lobed, those near the center closely imbricated and ascendant and often compacted into a granular and often gray-powdery crust, usually dark below where not obscured by the thin, black hypothallus; lower cortex very thin and sometimes scarcely developed; apothecia adnate, the disk commonly depressed, reddish brown or finally blackening, the margin not containing algal cells (in material seen), finally disappearing, rather small, 1 to 2 mm. in diameter; hypothecium pale to brownish; hymenium pale or pale brownish below and darker above; asci clavate; paraphyses commonly simple, the apices enlarged and usually brownish; spores simple, hyaline, ellipsoid-pointed, 20 to 28 μ long and 9 to 13 μ wide.

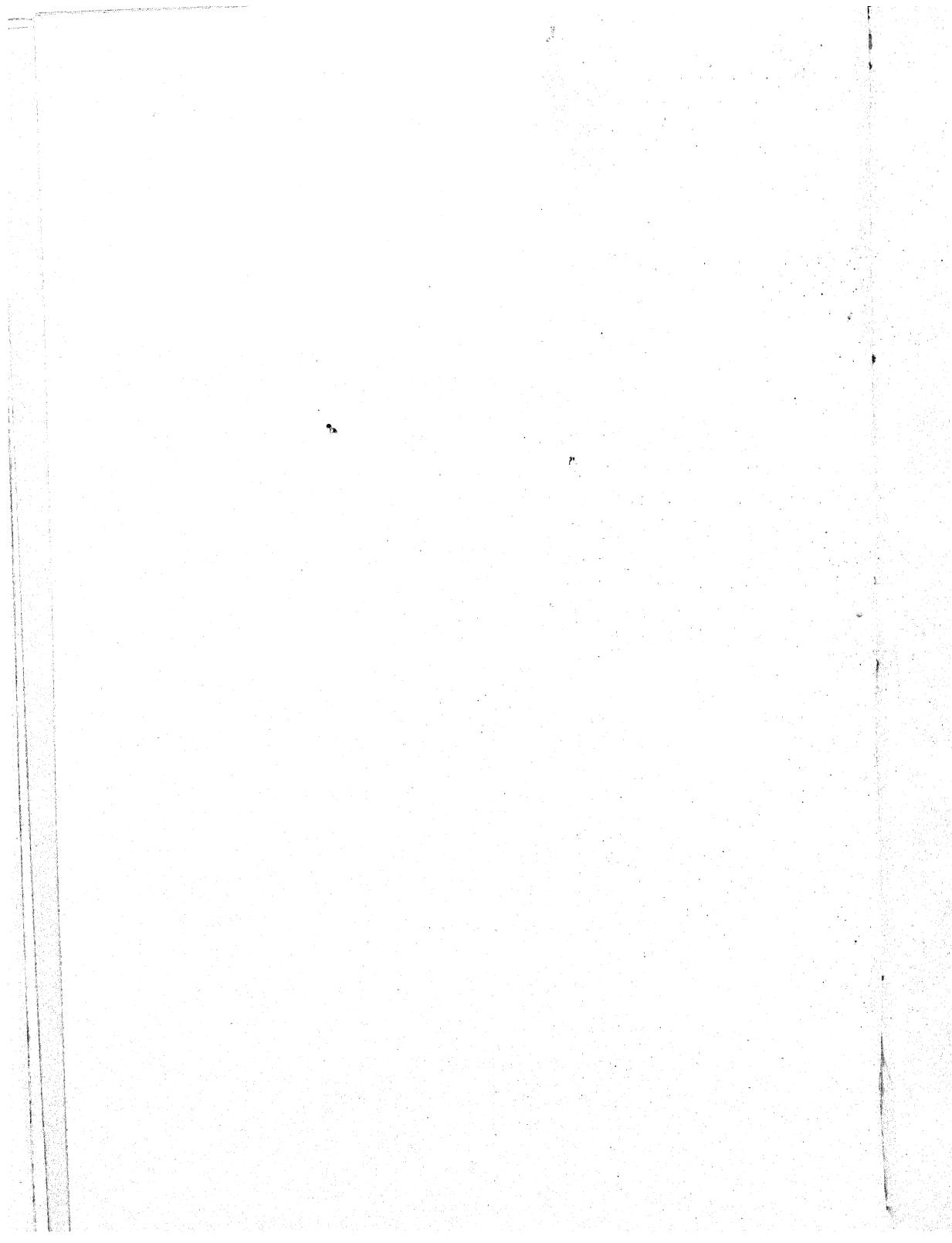
The fibrillose ring below the apothecia mentioned for Lake Superior specimens by Tuckerman has not been noticed in the material at hand.

Confined to the northeastern portion of the State. On rocks and wood.

Widely distributed in the northern United States and British America, but scarcely known to the South. Known also in Europe.



PANNARIA LEUCOSTICTA TUCK.



5. *Pannaria petersii* Tuck. Gen. Lich. 54. 1872.

Thallus squamulose-foliose, stellate, the lobes flat, clustered or scattered, radiately branched and many-cleft toward the circumference, frequently falling away at the center, olivaceous or black or rarely sea-green, the hypothallus absent, parenchymatous throughout, the lobes scarcely more than 0.5 mm. wide and reaching 1.5 to 3 mm. in length; plant when of definite form about 15 to 40 mm. in diameter; apothecia sessile, without thalloid exciple (biatoroid), the disk black and flat with a thin, raised margin, minute, 0.2 to 0.5 mm. in diameter; hypothecium light brown; hymenium pale below and slightly purplish above; paraphyses simple or branched, commonly thickened and purplish toward the apex; asci clavate; spores simple and 2-celled, oblong and ellipsoid, hyaline or pale, 12 to 24 μ long and 4 to 6 μ wide.

Collected on calcareous pebbles in the Leaf Hills in Ottertail County. The thallus was nearly obsolete, but the plant seems clearly to belong here.

A strictly North American lichen, hitherto reported from New York, Alabama, Tennessee, and Iowa.

6. *Pannaria nigra* (Huds.) Nyl. Not. Sallsk. Faun. Flor. Fenn. 5: 126. 1861.

Lichen niger Huds. Fl. Angl. ed. 2: 524. 1778.

Thallus composed of minute squamules, which are sometimes scattered but usually closely united into a more or less continuous granulose or coralloid crust, the slender lobes usually rounded, not exceeding 0.5 mm. in diameter, but sometimes branched and reaching 1 to 2 mm. in length in scattered conditions, lead-ashy in color, parenchymatous throughout; plants irregular in form and covering patches 15 to 50 mm. or more in diameter, resting upon and bordered by a prominent blue black hypothallus; apothecia sessile, without thalloid margin, the disk commonly black or more rarely reddish brown, flat or convex with a thin, elevated margin, which frequently disappears, minute, 0.3 to 0.8 mm. in diameter; hypothecium light brown or darker; hymenium pale below, and brownish or purplish above; asci clavate; paraphyses simple or rarely branched, commonly enlarged and colored toward the apex; spores oblong, 2 to 4-celled, 12 to 16 μ long and 4.5 to 7 μ wide.

Generally distributed in the State, but by no means common. On various rocks.

The plant from Grand Portage referred to *Pannaria flabellosa* belongs here.

Widely distributed in the United States and northward into British America and Alaska. Known in all the grand divisions.

Family STICTACEAE.

The family is represented in Minnesota by the genus *Sticta*, in which the algal symbiont is *Dactylococcus* or *Polycoccus*, both blue-green algae, or the green *Cystococcus*. The thallus is large, plainly foliose, prostrate upon the substratum and well lobed. The cellular cortex is well developed above and below. Cyphellae are usually present and constitute the most marked characteristic of the family. The apothecia are borne upon the upper surface of the thallus, scattered promiscuously, or marginal or submarginal. They vary from adnate to subsessile. The spores are 2 to 4-celled and hyaline or brown.

The relationship of the Stictaceae and the Pannariaceae was discussed under the latter family. As reasons for separating the Stictaceae from the Peltigeraceae following may be noted the general presence in the former of cyphellae and the different disposition of its apothecia. The presence may also be mentioned of upper and lower cortices in all the members of the former family and the absence of the lower cortex in most of the genera of the latter.

STICTA Ach. Lich. Suec. 3, 156, 257. 1798.

PLATE 26.

The thallus is foliose, commonly lobed and prostrate on the substratum, to which it is attached by rhizoids. The color is usually sea-green, yellowish, or brown. The cortex is developed both above and below, and the upper cortex is usually thicker than the lower. Underneath the lower cortex extend the rhizoids, and there are cyphellæ or naked spots on the lower side in most of the species. The medullary and algal layers occupy the usual positions. The algal symbiont is the common *Cystococcus* or probably *Dactylococcus* in the larger number of species. The genus has been variously divided, but there is scarcely any basis for such division at present and can not be until the plants included have been more thoroughly studied. The thallus is frequently pustulate, but the pustules are not conspicuous and they extend downward instead of upward as in *Umbilicaria pustulata*, thus forming a series of depressions which give the upper surface a reticulate appearance.

The apothecia are rather rare and are sessile on the upper surface, or are marginal or submarginal. The algae of the thalloid margin sometimes die, in which case the margin appears externally to be lecideoid, or the margin may be overgrown by the apothecium and thus disappear. The hypothecium sometimes shows two distinct layers, the upper a network of mostly vertical hyphæ and the lower a pseudocellular layer, formed of gelatinized hyphæ extending for the most part horizontally. The cellular nature of the lower layer is by no means constant. The color is usually pale brownish. The paraphyses are usually simple and the apices thickened and brownish. The spores are 2 to 4-celled and hyaline or brown, or only very slightly colored. Their form is spindle-shaped or acicular.

The genus is somewhat closely related to members of the next family.

Seven species are found in the State.

Type species *Sticta sylvatica* Ach. loc. cit.

EXPLANATION OF PLATE 26.—Fig. 1, a section of the thallus of a *Sticta*; *e*, a cyphella composed of a network of hyphæ and protruding from an opening in the lower cortex of the thallus. Fig. 2, the form of cyphella found in *Sticta damacornis*, consisting of a depression in the lower side of the thallus and surrounded by hyphæ composed of almost spherical cells. In figs. 1 and 2 the usual layers of the thallus are also shown; *a*, the dermis; *b*, the upper cortex; *c*, the algal layer; *d*, the lower cortex; between *c* and *d*, the medullary layer; *f*, the rhizoids. Figs. 1 and 2 enlarged 400 diameters. From Schneider.

KEY TO THE SPECIES.

Thallus without either cyphellæ or white spots below..... 1. *S. amplissima*.

Thallus having either cyphellæ or white spots below.

Thallus having white spots below.

Thallus lobes long and frequently truncate..... 2. *S. pulmonaria*.

Thallus lobes short and rounded..... 7. *S. scrobiculata*.

Thallus having cyphellæ below.

Cyphellæ sorediiform; thallus sea-green to brownish,
often having yellowish green soredia above..... 3. *S. crocata*.

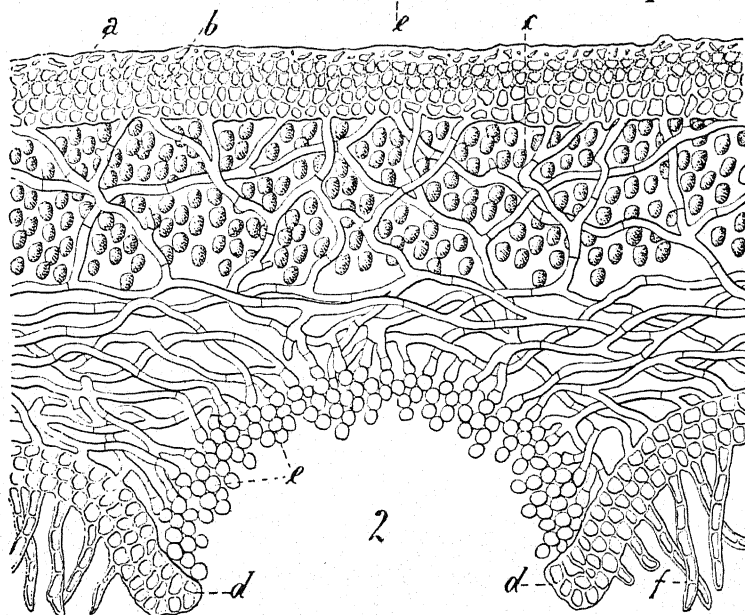
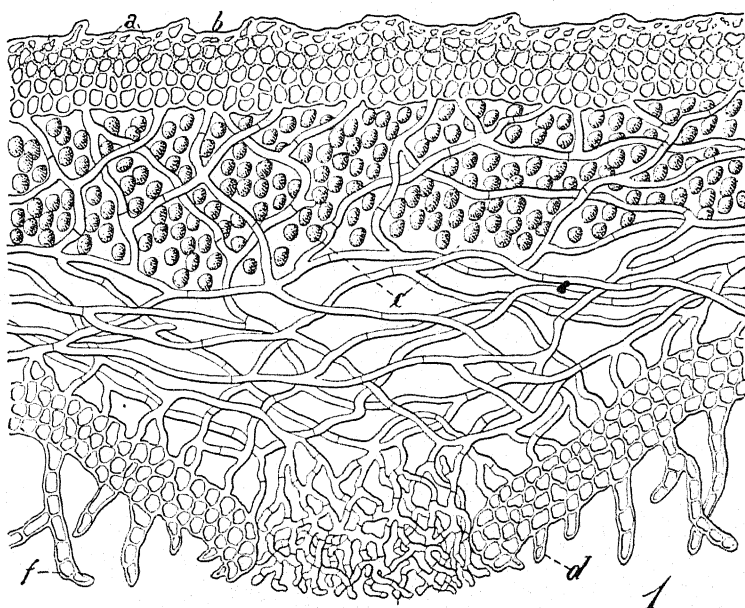
Cyphellæ not sorediiform.

Cyphellæ concave.

Thallus brown or lead-colored, clothed above
with blackish granules..... 5. *S. fuliginosa*.

Thallus as above, only not clothed with
granules..... 4. *S. limbata*.

Cyphellæ urceolate; thallus brown, varying toward
sea-green, more or less isidioid-granulose, espe-
cially toward the margin..... 6. *S. quercizans*.



CYPHELLÆ.



SPECIES OF STICTA, PARMELIA, PYXINE, ETC., IN A CEDAR SWAMP.

1. *Sticta amplissima* (Scop.) Mass. Mem. Lich. 28. 1853.*Lichen amplissimus* Scop. Fl. Carn. ed. 2. 2: 386. 1772.

Thallus rather closely adnate, more or less orbicular in outline, middle-sized or large, 6.5 to 20 cm. in diameter, smooth above or becoming more or less rugose, the lobes somewhat elongated and narrow or occasionally wider, sometimes more or less imbricated, with sinuate, subentire, or obscurely crenate margins; sea-green varying toward ash-color or brownish, below commonly lighter-colored and clothed usually with a spongy nap of small rhizoids with much larger rhizoids interspersed here and there, or the small rhizoids few or rarely wanting; devoid of cyphellæ or white spots and the rhizoids frequently becoming dark; apothecia subsessile, scattered, the disk concave, chestnut-colored, the margin entire or crenulate, middle-sized, 1 to 3 mm. in diameter; hypothecium pale or brownish; hymenium pale below and pale or brownish above; paraphyses simple, the apex usually thickened and brownish; asci clavate or ovate-clavate; spores hyaline to light brown, 2 to 4 celled, 30 to 65 μ long and 4.5 to 7 μ wide.

Distributed throughout the northern portion of the State. On trees and rocks, especially on cedars in swamps.

Distributed throughout the eastern half of North America, but toward the south for the most part confined to mountains. Known in all of the grand divisions except South America.

2. *Sticta pulmonaria* (L.) Schaer. Enum. Lich. Eur. 30. 1850.

PLATE 27.

Lichen pulmonarius L. Sp. Pl. 1145. 1753.

Thallus middle-sized or large, 6.5 to 21 cm. in diameter, rather loosely attached to the substratum, prominently pustulate-reticulate, tawny-olivaceous varying toward sea-green, frequently sorediate or isidioid above, laciniately lobed, the lobes elongated and frequently deeply and narrowly sinuate, with retuse-truncate ends; beneath clothed with small brownish rhizoids which give a villous surface, with naked, raised, and whitish spots interspersed; apothecia adnate, usually submarginal, the disk chestnut, convex, the thalloid margin thin, entire or wrinkled and finally disappearing, middle-sized, 1.5 to 4 mm. in diameter; hypothecium not distinctly 2-layered, pale brownish; hymenium pale below and pale or pale brownish above; paraphyses simple or branched, the apex somewhat thickened and brownish; asci clavate; spores cymbiform, hyaline or pale, 2 to 4 celled, 18 to 33 μ long and 5.5 to 9 μ wide.

Confined to the northern portion of the State. On trees and rocks.

Distributed throughout the eastern half of North America, but confined to the mountains toward the south. Also extending to the Pacific coast in British America and Alaska. Known also in all of the grand divisions.

EXPLANATION OF PLATE 27.—View in a cedar swamp showing *Stictas*, *Parmellas*, and *Pyxine sorediata* on the prostrate tree at the front. About one-fortieth natural size.

3. *Sticta crocata* (L.) Ach. Lich. Suec. 158, 257. 1798.*Lichen crocatus* L. Mant. Pl. 2: 310. 1771.

Thallus of medium size or larger, 5.5 to 14 cm. in diameter, rather loosely attached to the substratum, irregularly lacinate, more or less pitted or reticulately ribbed, commonly bordered and frequently more or less sprinkled above with yellowish green soredia, varying in color from sea-green to some shade of brown, the lobes wide and rounded with crenate or lacinate margins, more or less imbricated, below of the same color as above or darker, the rather small rhizoids forming a soft nap in which are scattered the more or less sorediiform cyphels; apothecia scattered or marginal, medium-sized with usually black disk, the thalloid margin crenate and more or less evanescent; spores 2-celled, brown, oblong-fusiform, 20 to 32 μ long and 9 to 10 μ wide.

Ours sterile, the spore and apothecial characters taken from Nylander.

Distributed throughout the northeastern portion of the State, as far west as Rainy Lake City and as far south as Duluth. On trees and also on shaded rocks.

Found in the mountains of the United States and descending to lower altitudes in the extreme northern portion and in British America and Alaska. Known in all of the grand divisions except Asia.

4. *Sticta limbata* (Turn.) Ach. Meth. Lich. 280. 1803.

Lichen limbatus Turn. in Sowerby, Engl. Bot. 16: pl. 1104. 1802.

Thallus rather loosely attached to the substratum, usually orbicular in outline with short rounded lobes, rather small, ours being only 2.5 to 4 cm. in diameter, smooth above or sometimes slightly scrobiculate, usually monophyllous, sometimes more or less sorediate toward or along the margins (not in ours); usually brown but varying toward lead-color, below paler and clothed with rhizoids forming a soft nap, in which are to be found the whitish depressed cyphellæ; apothecia scattered over the upper surface, adnate, convex, the thalloid margin disappearing early, the disk a dull black; small, 0.5 to 1 mm. in diameter; hypothecium brownish; hymenium brownish toward the base and darker brown above; paraphyses simple or branched, the apex thickened and brownish; asci clavate or ovate-clavate; spores brown, 2-celled, oblong-ovate, constricted, 15 to 20 μ long and 5 to 7 μ wide.

Once collected in the State. On trees at Tofte.

Previously reported in North America from Oregon, Alaska, and Labrador. Also known in Europe and a subspecies in Africa.

5. *Sticta fuliginosa* (Dicks.) Ach. Lich. Suec. 158, 257. 1798.

FIGURE 12.

Lichen fuliginosus Dicks. Pl. Crypt. Brit. 1: 13. 1785.

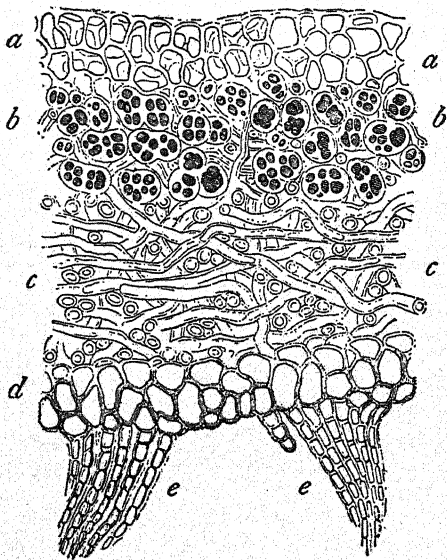


FIG. 12.—*Sticta fuliginosa*, showing a section of the thallus. *a*, The upper cortex; *b*, the algal layer; *c*, the medullary layer; *d*, the lower cortex; *e*, the rhizoids. Enlarged 500 diameters. From Sachs.

Thallus rather loosely attached to the substratum, more or less orbicular in outline, middle-sized, 2.5 to 12 cm. in diameter; more deeply lobed than the last, but the lobes still rounded, smooth above or slightly scrobiculate or more or less clothed with blackish granules, usually brownish above but frequently varying toward gray or lead-color, below paler and clothed with rhizoids, these forming a soft nap, in which are embedded the concave whitish cyphellæ; apothecia usually marginal, smallish, about 1 mm. in diameter, the thalloid exciple evanescent, the disk convex and reddish brown; spores pale or hyaline, 2 to 4-celled, 25 to 43 μ long and 7 to 9 μ wide. Ours sterile, the spore and apothecial characters from Nylander.

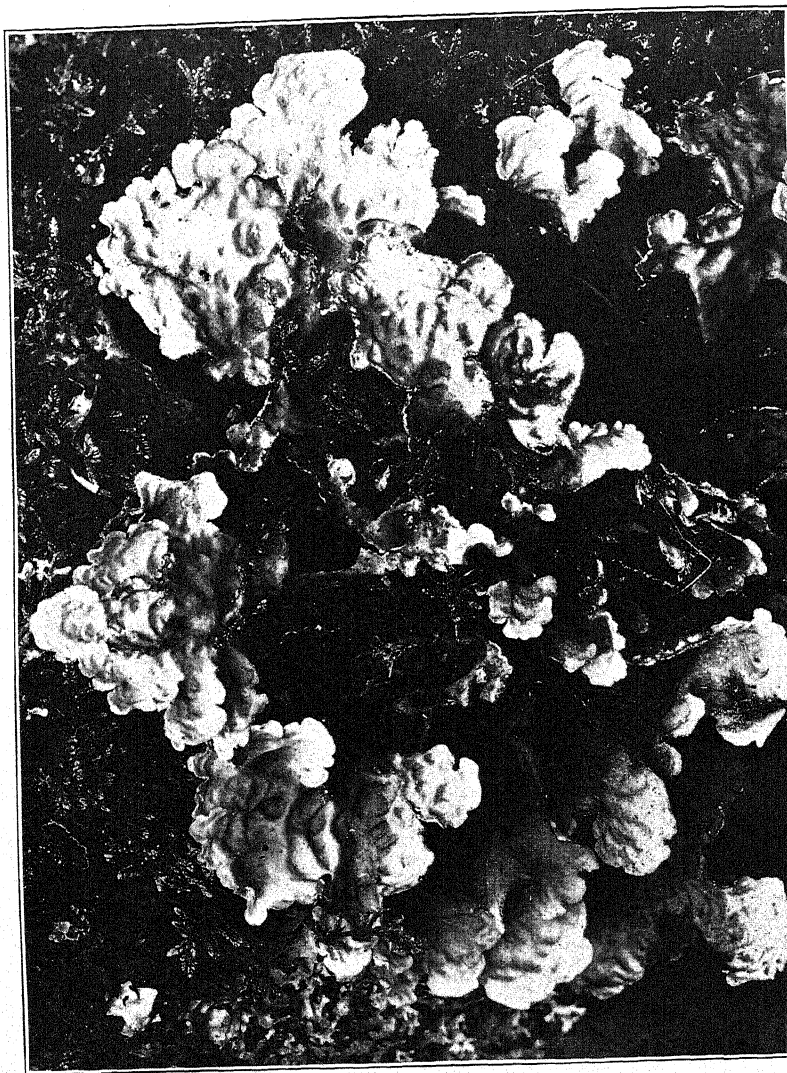
Confined to the northwestern portion of the State, occurring as far east and south as Tower. Usually on cedars in swamps. The species is so near to the last that the two are very difficult of separation.

A widely distributed species in North America. Known in all the grand divisions except possibly Asia.

6. *Sticta quercizans* (Michx.) Ach. Syn. Lich. 234. 1814.

Lobaria quercizans Michx. Fl. Bor. Amer. 2: 324. 1803.

Thallus more closely attached to the substratum, more or less orbicular in outline, middle-sized or large, 5 to 17.5 cm. in diameter, the lobes somewhat longer and



STICTA SCROBICULATA (SCOP.) ACH.

narrower and lacinate, with usually more or less raised entire or crenate margins, frequently somewhat imbricate, smooth above or more or less isidioid-granulate, especially along the margins; upper surface brown, varying toward sea-green but seldom showing the reddish tendency of more southern specimens; lower surface paler and clothed with light brown or darker rhizoids, these forming a spongy nap in which are embedded the urceolate whitish cyphellæ; apothecia usually submarginal, the disk reddish brown, the exciple thin, usually entire and finally losing its algal cells, middle-sized, 2 to 3 mm. in diameter; spores hyaline or pale, fusiform, 4-celled, 30 to 32 μ long and 8 to 9 μ wide.

Ours are uniformly sterile, and the above spore and apothecial characters are taken from Nylander.

Confined to the northern portion of the State. Commonly on cedars in swamps, but sometimes on rocks or other trees.

The plant is widely distributed in North America. Also known in all the grand divisions except Europe.

7. *Sticta scrobiculata* (Scop.) Ach. Lich. Univ. 453. 1810

PLATE 28.

Lichen scrobiculatus Scop. Fl. Carn. ed. 2. 384. 1772.

Thallus somewhat loosely attached to the substratum, more or less orbicular in outline, middle-sized or larger, 4.5 to 15 cm. in diameter, smooth and scrobiculately pitted and clothed more or less with grayish soredia, sea-green, varying toward yellow, the lobes short and rounded with undulate or crenate margins, below clothed with usually dark rhizoids, giving a villous surface interspersed here and there with light naked spots, these resembling somewhat in appearance the cyphellæ of our other *Stictas*; apothecia scattered, small to middle-sized, sessile, the disk reddish brown, the margin entire; hypothecium rather indistinctly 2-layered, the upper layer thinner and brownish, the lower wider and pale; hymenium pale or brownish; paraphyses frequently branched, the apex often enlarged and brownish; asci ovate-clavate; spores long-fusiform, 4 to 8-celled, hyaline or pale, 50 to 75 μ long and 5 to 7 μ wide.

Ours are always sterile, and the spore and apothecial characters were taken from European specimens.

Found only along the north shore of Lake Superior. On mossy rocks or on trees.

Frequent in New England and northward throughout the eastern half of British America and found also in Alaska. Known also in Europe, Asia, and Africa.

EXPLANATION OF PLATE 28.—Plant on a mossy trunk, showing the characteristic lobed and pitted thallus. Natural size.

Family PELTIGERACEAE.

The family as represented in our flora includes three genera, of which *Peltigera* may be regarded as the most typical. In this there is a total absence of lower cortex, though the species are usually large and have foliose thalli not more closely attached to the substratum than are members of the *Stictaceae*. However, in the genus named above, the lower cortex is more or less replaced by a layer of hyphæ running horizontally below the medullary layer. The trichomatic hyphæ are also usually present in the species. In one of the other two genera, *Solorina*, the lower cortex is scarcely developed, but in the other, *Nephroma*, it is well developed. *Solorina* is thus more nearly typical as regards the cortex, but the genus is somewhat aberrant in that the apothecia are scattered over the upper surface of the thallus and not confined to the lobes as in the other two genera. In *Nephroma* there is a well developed cortex below, and in this respect the genus is the highest member of the family. The apothecia of *Nephroma* are typical of the family in that they are immersed in the lobes, but their location is peculiar in being removed to the lower side of the lobes.

The relationship of the present family with the last was stated under that family. The spore characters and the algal symbionts are indicated in the Outline of Classification and under the several genera.

With the Peltigeraceae we reach the climax in a line of development in lichens, conducted hither through several closely related families. Accordingly the present family does not show close relationship with any of the families to follow.

SOLOIRINA Ach. Lich. Univ. 27, 149. *pl. 1. f. 5, 6.* 1810.

The thallus is foliose, rather indistinctly lobed, prostrate but rather loosely attached to the substratum. Its structure resembles that of Peltigera in the absence or very rudimentary development of the lower cortex. The upper cortex is present, and is frequently thick in some areas and thin in others. Two kinds of algæ occur in the same plant, supposed to be Dactylococcus and a Polycoccus. The former predominates and commonly lies for most part above the other, extending nearly to the upper surface below the thin places in the upper cortex. The medullary layer is well developed and extends below into a thicker layer of hyphæ, lying for the most part in a horizontal position. Bundles of hyphæ form ridges or veins on the lower surface similar to the veins of Peltigera. Rhizoids are more or less common, extending downward from the lower surface.

The apothecia as a whole resemble those of Peltigera, though they are scattered over the upper surface and are even more common near the center instead of being marginal. They are commonly impressed, though they may be more or less raised. The thalloid margin is usually wanting, but may be made out occasionally, especially when the apothecia are somewhat raised. The hypothecium and the hymenium are pale or else light or darker brownish. The paraphyses are commonly simple and the spores are 2-celled and brown.

The close relationship of the genus to Peltigera as regards structure of thallus and apothecia has already been noted. The spore characters of the two genera, however, are so different that the relationship can not be as close as would be supposed from a consideration of the thallus and apothecia alone.

A single species occurs along the shores of Lake Superior. On earth or mossy rocks.

Type species *Solorina crocea* (L.) Ach. loc. cit.

Solorina saccata (L.) Ach. Lich. Univ. 149. *pl. 1. f. 6.* 1810.

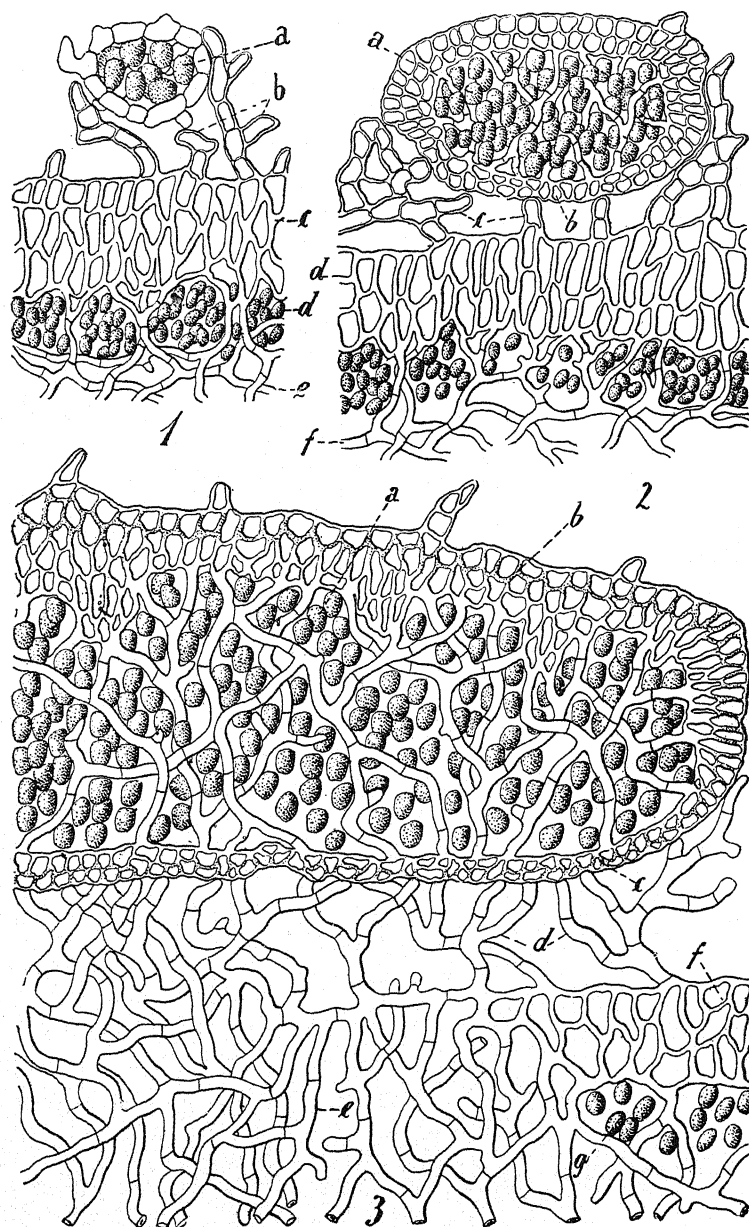
PLATE 23, B.

Lichen saccatus L. Sp. Pl. ed. 3. 1616. 1764.

Thallus foliose, rather loosely attached to the substratum, smoothish above, more or less orbicular, small or middle-sized, 20 to 75 mm. in diameter, the lobes rather short, wide and rounded, the ends subentire or more or less irregularly incised, sea-green, varying toward ashy or brownish, below lighter in color, but sometimes darkening, cottony and obscurely veined and rhizoid-bearing, the upper cortex quite uniform in thickness; apothecia commonly sunken into the thallus, the disk more or less concave, dark brown, the thalloid margin seldom distinguishable, middle-sized, 2 to 6 mm. in diameter; hypothecium light brown; hymenium pale below and pale brownish above; paraphyses commonly simple, frequently enlarged and brownish toward the apex; asci cylindrical; spores ellipsoid, 40 to 60 μ long and 16 to 22 μ wide.

The plant is rare in Minnesota. It has been collected on mossy rocks at Grand Portage and near Pork Bay, thus apparently confined to the shore of Lake Superior.

Scattered across the northern United States from the Rocky Mountains to the Atlantic Ocean, but confined for the most part to mountains or cold shores. More generally distributed throughout British America. Also known in Europe and Asia.



CEPHALODIA OF PELTIGERA APHTHOSA (L.) WILLD.

PELTIGERA Willd. Fl. Berol. Prodr. 347. 1787.

PLATE 29.

The thallus is foliose, more or less lobed and rather loosely attached to the substratum. The common color is sea-green varying toward brown. The structure is peculiar in the total absence of a lower cortex, while there is a well developed upper one. The algal layer is in the usual position just below the cortex, and the portion of the thallus below the algal layer is somewhat differentiated, in that the hyphæ of the lower portion run in a somewhat horizontal direction and together with the usually numerous rhizoids serve for support and also for protection against too rapid evaporation of moisture, thus functioning somewhat like a true cortex. The plants are usually more or less veined below. In some of the species the upper surface is more or less clothed with hyphæ, which give a downy appearance and which are structurally and functionally comparable to the trichomes of higher plants. These hyphæ have thick walls, and the cells are short. The algal symbiont is doubtless nearly always *Polycoccus* or *Dactylococcus*, though the chains of cells can hardly be discerned. In one of our species cephalodia occur on the upper surface of the thallus.

The apothecia are usually orbicular, and are found on the margins of the lobes of the thallus. They are usually immersed in the lobes and present somewhat the appearance of those of *Heppia* and *Solorina*. The hypothecium is pale or slightly colored. The hymenium is commonly brownish above. The paraphyses are commonly simple, though branched forms may be found in all of the species. The spores are fusiform or acicular, 4 to 8-celled, hyaline, or brownish, and frequently more or less curved.

Notwithstanding the absence of a lower cortex, there is a somewhat close relationship between the present genus and *Nephroma* and *Sticta*.

Eight species occur in the State, and one of them is represented by five distinct forms. On earth or more rarely on old wood or rocks.

Type species *Peltigera aphthosa* (L.) Willd. loc. cit.

EXPLANATION OF PLATE 29.—Cephalodia of *Peltigera aphthosa*. Fig. 1, *a*, a young cephalodium; *b*, the trichomatic hyphæ holding the cephalodium. Fig. 2, an older cephalodium; *a*, the internal hyphæ and algal cells; *b*, the well-developed cortex; *c*, the supporting trichomatic hyphæ. Fig. 3, a mature cephalodium; *a*, the internal hyphæ and algal cells; *b*, the upper cortex; *c*, the lower cortex; *d*, the supporting hyphæ; *e*, the thallus below the cephalodium, where the algal cells have disappeared and the cortex is transformed into hyphal tissue; *f*, the cortex; *g*, the algal layer of the supporting thallus. Fig. 1, enlarged about 100 diameters; fig. 2, enlarged 400 diameters; fig. 3, enlarged 200 diameters. From Schneider.

KEY TO THE SPECIES.

- | | |
|---|-----------------------------|
| Thallus cephalodia-bearing above..... | 1. <i>P. aphthosa</i> . |
| Thallus not cephalodia-bearing above. | |
| Thallus devoid of trichomatic hyphæ above. | |
| Thallus lobes small and roughly fan-shaped. | 2. <i>P. venosa</i> . |
| Thallus lobes larger, not fan-shaped. | |
| Apothecia-bearing lobes more or less digitately clustered; spores 4 to 8-celled, elongated..... | 4. <i>P. polydactyla</i> . |
| Apothecia-bearing lobes not digitately clustered; spores 4-celled, much shorter..... | 3. <i>P. horizontalis</i> . |
| Thallus having trichomatic hyphæ above. | |
| Margins of the lobes frequently isidioid-granulate, lobulate or sorediate..... | 5. <i>P. scutaria</i> . |
| Margins not isidioid and not lobulate or sorediate. | |
| Lower surface of the thallus partly or wholly brownish or blackish. | |
| Apothecia orbicular..... | 6. <i>P. malacea</i> . |
| Apothecia oblong or revolute..... | 7. <i>P. rufescens</i> . |

Lower surface of the thallus whitish.

Thallus middle-sized.

Rhizoids moderately developed 8. *P. canina*.

Rhizoids numerous and forming a spongy
nap 8a. *P. canina spongiosa*.

Thallus smaller or thinner.

Thallus thinner but expanded 8d. *P. canina leucorhiza*.

Thallus smaller.

Thallus scarcely rhizoid-bearing, but
sorediate 8c. *P. canina sorediata*.

Thallus scarcely rhizoid-bearing, not
sorediate 8b. *P. canina spuria*.

1. *Peltigera aphthosa* (L.) Willd. Fl. Berol. Prodr. 347. 1787. PLATES 29, 30.

Lichen aphthosus L. Sp. Pl. 1148. 1753. ^a

Thallus somewhat closely attached to the substratum, with the margins or the entire lobes more or less ascending, middle-sized to large, 6 to 20 cm. in diameter, sprinkled more or less with the small and irregular cephalodia, smooth above and devoid of trichomatic hyphæ, except those lying below and closely adhering to the cephalodia to hold them in place, the lobes broad and rounded and sometimes more or less imbricated, the margins subentire or more commonly somewhat crisped and variously irregular; from apple-green to sea-green or rarely even brownish, below white and rarely white-veined, but the veins more commonly dark and even the whole surface becoming so, the veins clothed with delicate rhizoids, these composing a close nap, the surface also bearing scattered larger rhizoids; apothecia on somewhat extended lobules, middle-sized or larger, 4 to 8.5 mm. in diameter, ascendant, frequently becoming revolute or convolute, often superficial, the margin entire or crenulate, the disk reddish brown; hypothecium brownish; hymenium pale or brownish below and darker above; paraphyses simple or rarely branched, commonly thickened and brownish toward the apex; asci cylindrico-clavate; spores acicular, colorless or showing pale brownish in the asci, 4 to 8-celled, 45 to 75 μ long and 4 to 7 μ wide.

Generally distributed over the northern portion of the State. On earth and frequently on humus-covered rocks.

Distributed much as the next in North America, but extending southward, at least in the mountains. Also known in Europe and Asia.

EXPLANATION OF PLATE 30.—Plant on earth, showing the ascending thallus lobes dotted over with cephalodia. Natural size.

2. *Peltigera venosa* (L.) Hoffm. Deutsch. Fl. 2: 107. 1795.

Lichen venosus L. Sp. Pl. 1148. 1753.

Thallus usually composed of scattered lobes, each of which may be regarded as a plant, or rarely more or less connected into a larger thallus, the single or more rarely united lobes somewhat ascending, commonly more or less fan-shaped or in the form of an isosceles triangle, smooth and devoid of trichomatic hyphæ above, sea-green varying toward ashy or brownish, the margins of the nonfertile lobes entire or somewhat wavy, below white between brown veins, the latter bearing small rhizoids and sometimes spreading until they cover nearly all of the lower surface, the lobes 8 to 20

^aThe original spelling was by error *aphtosus*.



PELTIGERA APHTHOSA (L.) WILLD.

8

mm. long and frequently as wide at the anterior end so that they become roughly equilateral; apothecia along the margins, usually the anterior margin, superficial and rounded, with entire or crenulate, thalloid, but commonly brown and apparently biatoroid exciple, horizontal with flat brown to blackish disk, middle-sized, 2 to 5 mm. in diameter; hypothecium brown or brownish; hymenium pale or brownish below and darker above; paraphyses simple or rarely branched, enlarged and brownish toward the apex; asci cylindrico-clavate; spores fusiform, frequently pale brown, 28 to 45 μ long and 6 to 9 μ wide, but rarely longer, and 5-celled instead of 4-celled in ours.

Collected at Grand Portage and at South Fowl Lake. On earth and mossy rock; a rare plant in Minnesota.

Widely distributed in the northern portion of the United States, especially in mountainous country, and common northward to arctic America. Known also in Europe and Asia.

3. *Peltigera horizontalis* (L.) Hoffm. Deutsch. Fl. 2: 107. 1795.

Lichen horizontalis L. Mant. Pl. 2: 132. 1771.

Thallus somewhat closely attached to the substratum, but the margins of the lobes more or less ascending, middle-sized or larger, 6 to 19.5 cm. in diameter, the upper surface usually smooth and shining and devoid of trichomatic hyphæ, the margins of the wide lobes rounded and entire, undulate, or variously irregular, sea-green varying toward ashy brown, or reddish brown, below bearing large rhizoids commonly dark in color and smaller ones of the same colors, the latter forming a close nap, the nap and larger rhizoids usually lighter-colored toward the margin; veins not conspicuous in ours; apothecia on somewhat narrowed lobes, submarginal and frequently superficial, middle-sized, 3 to 5 mm. in diameter, transversely oblong, commonly flat, the disk reddish brown; hypothecium commonly brownish; hymenium pale, or brownish above; paraphyses simple or rather rarely branched, usually enlarged and brownish toward the apex; asci cylindrico-clavate; spores 4-celled, 30 to 48 μ long and 5.5 to 8 μ wide.

Distributed throughout the northern portion of the State. On earth in swamps and rarely over mossy rocks.

The plant is widely distributed in North America. Known also in Europe and Africa.

4. *Peltigera polydactyla* (Neck.) Hoffm. Deutsch. Fl. 2: 106. 1795.

Lichen polydactylon Neck. Meth. Musc. 85. 1771.

Thallus attached much as in the last and of about the same size, likewise having ascending lobes and smooth, shining upper surface devoid of trichomatic hyphæ, the margins of the lobes much as in the last, except those bearing apothecia, these usually digitately clustered and more elongated, sea-green, lead-colored, or rarely becoming brownish, below bearing rhizoids as in the last, but on the whole lighter-colored, reticulated with commonly brown or darker veins and not conspicuously covered with nap, lighter toward the margin; apothecia middle-sized, 3 to 5 mm. in diameter, rounded or more commonly revolute, the disk reddish brown; hypothecium commonly brownish; hymenium pale, or brownish above; paraphyses simple or rarely branched, commonly thickened and brownish toward the apex; asci clavate or cylindrico-clavate; spores 4 to 8-celled, 60 to 100 μ long and 3 to 4 μ wide.

This species and the last are very difficult to distinguish macroscopically, but the spore characters are perfectly distinct.

Confined to the northern portion of the State, a single specimen recorded from Minneapolis being doubtful. On earth, especially in swamps.

Generally distributed throughout North America. Known in all of the grand divisions.

5. *Peltigera scutata* (Dicks.) Leight. Lich. Fl. Great Brit. 110. 1871.

Lichen scutatus Dicks. Pl. Crypt. Brit. 3: 18. 1793.

Thallus much as in the last, but not so uniformly smooth and sometimes having trichomatic hyphæ over at least portions of the upper surface, rather small to middle-sized, 6 to 14.5 cm. in diameter, the margins of the lobes usually rounded, crisped and frequently isidioid-granulate or isidioid-lobulate (not sorediate in ours), the fertile ones short and scattered, sea-green varying toward ashy or brownish, beneath light with brown veins, or in ours the whole lower surface, except the margins, becoming dark brown; apothecia rather smaller than in the last, orbicular or transversely oblong, the disk reddish brown; spores 4 to 8-celled, 50 to 70 μ long and 3 to 4 μ wide.

Typical forms not fruited in ours, and spore and apothecial characters taken from Tuckerman.

Recorded from Minneapolis and Taylors Falls as *Peltigera pulverulenta* (Tayl.) Nyl.^a The best forms seem to differ sufficiently from either of the last two, but in the absence of fruit, the plants here recorded must be regarded as uncertain. A peculiar feature both in Iowa and Minnesota plants is the fact that the thallus is quite commonly found growing over blackened, dead thalli of the same kind, sometimes three or more layers thus appearing one above another. On earth, usually under trees.

Seems to be widely distributed in North America, though not often collected. Known also in Europe.

6. *Peltigera malacea* Ach. Syn. Lich. 240. 1814.

Thallus rather more loosely attached to the substratum and the lobes perhaps more ascending than in most of the species, middle-sized, 6.5 to 15 cm. in diameter, the upper surface commonly not so smooth and shining, but finely granular or even minutely downy, owing to the presence of scattered or more numerous trichomatic hyphæ, sea-green, varying toward ashy or more commonly toward brownish, the lobes somewhat narrower, rounded with entire or undulate margins, beneath light-brown to blackish, but paler and sometimes white-foveolate toward the margin, larger rhizoids few or absent, and the surface scarcely veined but uniformly clothed with a dense nap; apothecia on extended lobes, middle-sized or larger, 3 to 7.5 mm. in diameter, orbicular, the disk brownish-black; hypothecium dark brown; hymenium pale brown below and darker above; paraphyses simple or rarely branched, commonly enlarged and brown toward the apex; asci cylindrico-clavate; spores 4 to 6-celled, 50 to 75 μ long and 4 to 6 μ wide.

The plant has been found at Grand Marais, at Tower, and westward from Kettle Falls along the international boundary. On thin earth over rocks.

Known in the White Mountains, the Rocky Mountains, and northward to Newfoundland and Greenland. Found in all of the grand divisions except Australia.

7. *Peltigera rufescens* (Neck.) Hoffm. Deutsch. Fl. 2: 107. 1795.

Lichen rufescens Neck. Meth. Musc. 79. 1771.

Thallus closely adnate with ascending margins, scarcely middle-sized, 6 to 12.5 cm. in diameter, the upper surface rather sparingly covered with trichomatic hyphæ and downy or entirely devoid of them and smoother, the lobes more crowded and narrower than in the next with elevated and crisped margins, sea-green or more commonly becoming brown or reddish brown, beneath reticulated with brown veins, these more or less rhizoid-bearing, in ours the whole lower surface, except toward the margins, becoming dark brown; apothecia on extended lobes, middle-sized or larger, 3.5 to 7.5 mm. in diameter, becoming vertical, oblong or revolute, the disk reddish brown varying toward blackish; hypothecium brown or brownish; hymenium commonly pale brownish below and darker above; paraphyses simple or rarely branched,

^aNyl. Syn. Meth. Lich. 1: 325. 1858.

the tips usually enlarged and brownish; asci long-clavate; spores 4 to 8-celled, 40 to 65 μ long and 3 to 5 μ wide.

The plant has been noted in all parts of the State except the northeastern portion, but much of the material is uncertain and may belong in some instances to the next or more probably to *Peltigera scutata* (Dicks.) Leight. There is a form which seems to belong distinctly to the above description, but there is much confusion both in America and in Europe as to the relation of the present species and the next, a fact that is apparent enough in examining the exsiccati of the best lichenists.

On earth under trees, on rocks or on the bases of tree trunks.

The plant is widely distributed in North America. Known in all of the grand divisions.

8. *Peltigera canina* (L.) Hoffm. Deutsch. Fl. 2: 106. 1795.

FIGURE 13.

Lichen caninus L. Sp. Pl. 1149. 1753.

Thallus closely adnate toward the center, but more or less ascending toward the margins of the lobes, middle-sized to large, 7.5 to 25 cm. in diameter, the upper portion clothed for the most part with trichomatic hyphæ, giving a downy appearance

under the lens, the lobes widely with usually rounded but sometimes irregular or crenate margins or even much crisped, sea-green to brownish, below whitish or rarely brownish toward the center, with veins and rhizoids of the same color; apothecia middle-sized or larger, 4 to 8 mm. in diameter, on long and usually nearly erect lobes, rounded more commonly semirevo-

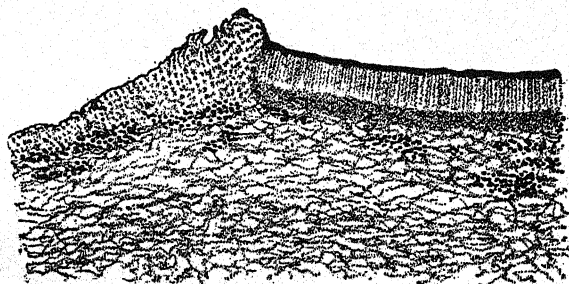


FIG. 13.—*Peltigera canina*. Section of a portion of an apothecium, showing immersion. Enlarged 45 diameters. From Reinke.

lute, the disk reddish brown, becoming vertical; hypothecium brownish; hymenium usually pale below and brownish above; paraphyses simple or rarely branched, frequently enlarged and brownish toward the apex; asci long-clavate; spores 4 to 8-celled, 38 to 72 μ long and 3 to 5 μ wide.

Generally distributed over the State. Habitats as in the last.

Found in all portions of North America, but preferring mountains to the south. Known in all of the grand divisions except Australia.

8a. *Peltigera canina spongiosa* Tuck. Gen. Lich. 38. 1872.

The pale veins of the lower side passing into tufted rhizoids, of the same color or darkening, these frequently running together into a conspicuous spongy nap.

Ours are large plants, and the trichomatic hyphæ are usually large and numerous. Commonly sterile.

Rare in the northern portion of the State, and a single doubtful specimen has been recorded from Redwood Falls. On earth or over mosses in swamps.

The subspecies is recorded from a few localities in the northern United States and is more common northward, extending into arctic regions. An American form, known only in North America.

8b. *Peltigera canina spuria* (Ach.) Tuck. Gen. Lich. 38. 1872.

Lichen spurius Ach. Lich. Suec. 159. 1798.

The cream-colored veins of the lower side scarcely rhizoid-bearing, the fertile lobules somewhat digitately clustered, the whole thallus including the apothecia reduced in size, lobes 15 to 45 mm. in length. Not differing microscopically.

Generally distributed over the State. On earth and old wood.

The North American distribution seems to be about the same as that of the species. Also known in Europe and Asia.

8c. *Peltigera canina soorediata* (Schaer.) Fink, Bull. Lab. Nat. Hist. Univ. Iowa 3: 76. 1895.

Peltigera canina spuria soorediata Schaer. Enum. Lich. Eur. 21. 1850.

Thallus small, composed of usually scattered lobes, these soorediate and 10 to 45 mm. in length, the ends usually rounded and sterile; beneath either bearing rhizoids or not; apothecia rather smaller than in the species, not differing microscopically.

Found in all portions of the State. On earth or old logs in moist shaded places.

North American distribution the same as that of the last, into which it frequently passes. Known also in Europe.

8d. *Peltigera canina leucorrhiza* Floerke, Deutsch. Lich. no. 53. 1821.

Thallus rather expanded and thinner, the conspicuous veins and scattered rhizoids white. The largest fern of the species, reaching 27.5 cm. in diameter, or the large rounded lobes scattered. Usually sterile; trichomatic hyphae abundant and large; apothecia not seen.

Found in the northern portion of the State. On earth or over mosses in swamps.

Agrees with material determined from Newfoundland by Arnold. Nothing further known of its American distribution. Known in Europe.

NEPHROMA Ach. Lich. Univ. 101, 521. pl. 11. f. 1. 1810.

The thallus is foliose and bears a general external resemblance to that of *Peltigera*, though smaller, usually darker in color and devoid of trichomatic hyphae. It lies horizontally on the substratum, to which it is usually more or less closely attached by rhizoids. The cortical layer is developed on both sides, the upper cortex being much thicker than the lower. The algal and medullary layers are well developed. There is some uncertainty regarding the algal symbiont, and Nylander has divided the genus, establishing the genus *Nephromium*, the distinction being based upon the difference in the algae. All of our species would fall under his newer genus were we to follow his distinction. However, we have retained the older name, awaiting further studies. The algae in ours are blue-green, and seem to be the same as in *Peltigera*, viz, *Polycoccus*.

The apothecia are confined to the lower side of the thallus, and this feature serves to distinguish the members of the genus from members of closely related genera as *Peltigera* and *Solorina*. However, the apothecia are marginal or submarginal, and the disk is more or less turned upward and may even stand erect. They are of good size, somewhat impressed in the more or less elongated lobes which bear them. The algal cells commonly disappear from the thalloid margin, which may itself be evanescent. The hypothecium is pale or brownish. The paraphyses are commonly simple with apices enlarged and brownish. The spores are brown or brownish, and commonly 4-celled in ours.

The genus is certainly closely related to *Peltigera* as to apothecial characters and also as regards general appearance of the thallus. As regards microscopic features of the thallus and the spores, it seems nearer to *Sticta*.

Four species and subspecies have been found in the northern portion of the State, a single species extending as far south as Taylors Falls.

The plants occur on trees, rocks, and occasionally on soil, and are quite commonly found on mosses overrunning these substrata.

Type species *Nephroma polaris* Ach. loc. cit. (*Nephroma arctica* (L.) Fr.)

KEY TO THE SPECIES.

- Thallus more or less tomentose above..... 1. *N. tomentosa*.
 Thallus not tomentose above.
 Tomentose beneath..... 2. *N. helvetica*.
 Without rhizoids beneath.
 Without soredia above..... 3. *N. laevigata*.
 Bearing soredia above..... 3a. *N. laevigata parv-
 ilis*.

1. *Nephroma tomentosa* (Hoffm.) Koerb. Syst. Lich. 56. 1855.

Peltigera tomentosa Hoffm. Deutsch. Fl. 2: 108. 1795.

Thallus somewhat closely attached to the substratum by means of the larger rhizoids, more or less orbicular in outline, middle-sized or larger, 5 to 12.5 or even rarely 20 cm. in diameter, the upper surface more or less tomentose at least along the margins; from sea-green varying to lead-colored or brown, the lobes not much elongated, except the fertile ones, sinuately cut with the ends subentire or crenate, beneath light-colored, tomentose with small rhizoids usually interspersed with larger ones, quite commonly more or less beset with small whitish tubercles (pseudocypellæ); apothecia frequent, the disk reddish brown, the thalloid margin frequently persistent and entire or irregularly crenulate; middle-sized to large, 2 to 12 mm. in diameter; hypothecium brownish or pale; hymenium pale, or pale brownish above; paraphyses commonly simple, the apex usually somewhat thickened and brownish; asci clavate; spores light brown, fusiform to oblong, 4 to 6-celled, 19 to 25 μ long and 4 to 6 μ wide.

Confined to the northern portion of the State. On rocks and trees.

Found from the Atlantic to the Pacific in the extreme northern portion of the United States and northward throughout British America and Alaska. Known in all the grand divisions except South America and Australia.

2. *Nephroma helvetica* Ach. Lich. Univ. 523. 1810.

Thallus quite similar to that of the last, but smaller (40 to 90 mm. in diameter) and more irregular in form, not tomentose above, but the margins and frequently the upper surface bearing tooth-like branchlets, sea-green or more commonly more or less brown, more deeply, narrowly, and sinuately or laciniately lobed than the last with the ends of the lobes scarcely ever even subentire, but either lacinate or somewhat irregularly crenate; beneath finely and less constantly tomentose than in the last, the color commonly darker or even blackish, the tubercles wanting; apothecia frequent, the disk reddish brown or darker, the margin as in the last, middle-sized, 1.5 to 6 mm. in diameter; hypothecium pale or brownish; hymenium pale beneath and pale or brownish above; paraphyses commonly simple, the apex usually thickened and brownish; asci clavate, the apical wall somewhat thickened; spores brown, ellipsoid to subfusiform, 4-celled, 15 to 22 μ long and 5 to 8.5 μ wide.

Confined to the northern portion of the State, but once collected as far south as Taylors Falls. On rocks or trees or rarely on earth.

Widely distributed in North America. Known in all the grand divisions.

3. *Nephroma laevigata* Ach. Syn. Meth. Lich. 242. 1814.

Thallus irregular or somewhat orbicular-rosulate, smooth or somewhat wrinkled above, sea-green or more commonly brown in color, the lobes rounded and undulate, beneath usually pale and wrinkled and quite devoid of rhizoids, though often roughened with what appear under the microscope as very short rhizoids; apothecia rather rare in ours, the disk reddish brown, small to middle-sized, 2 to 5.5 mm. in diameter, the thalloid margin entire in the material at hand; hypothecium brownish; hymenium pale below and pale or brownish above; paraphyses simple or rarely branched, the apices usually thickened and brownish; asci clavate; spores fusiform-ellipsoid, light brown, 4-celled, 16 to 22 μ long and 4 to 6.5 μ wide.

Found only in the northern portion of the State. On rocks and trees.

North American distribution essentially the same as that of *Nephroma tomentosa*, though not thus far collected within the United States to the west. Occurs in all of the grand divisions except Asia.

3a. *Nephroma laevigata parilis* (Ach.) Tuck. Syn. N. A. Lich. 1: 104. 1882.

Lichen parilis Ach. Lich. Suec. 164. 1798.

Thallus lobes sprinkled, especially at the margins, with gray soredia and more frequently darker or even blackish below.

Said to be thinner and softer than the type. Ours always sterile.

Collected at Kettle Falls and at Grand Portage. On rocks.

In New England and widely distributed in British America. Also known in South America, Europe, and Asia.

Family **GYROPHORACEAE.**

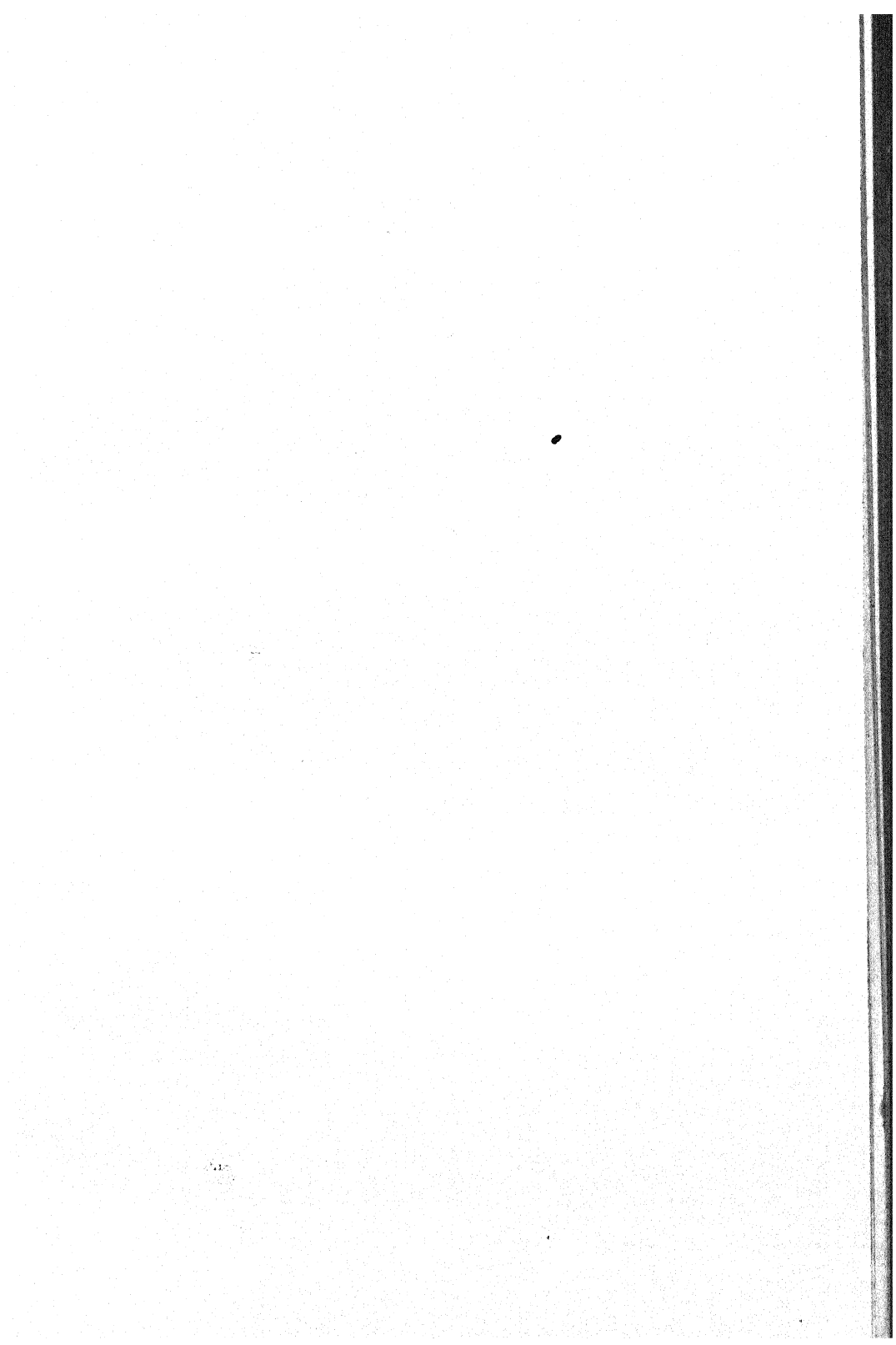
The family has two genera, Gyrophora and Umbilicaria. If we take into account thallus structure and likewise the peculiar disposition of the apothecia, the family is sufficiently distinct. Tuckerman did not divide into two genera, but recognized the family as consisting of the single genus Umbilicaria. He regarded the family as related to the Parmeliaceae and the Physciaceae through the foreign Omphalodium. However, the relation is by no means close, as comparison of both vegetative and reproductive tracts will reveal. Schneider, on the other hand, sees in the two genera of the present family the highest expression of the Lecideaceae and places both genera in that family. Yet this position seems hardly tenable, and it does not appear that the present family is more closely related to the Lecideaceae, as limited in this volume, than to the Parmeliaceae or the Physciaceae.

In the development of a strong central attaching organ, the umbilicus, and in the external appearance and the anatomical structure of the thallus, there is a considerable resemblance to the better developed Dermatocarpons, but when we consider the difference in apothecial structure it appears that the relationship here is also rather remote. Thus it seems that the family is a very distinct one, whose relationships are difficult to trace. Perhaps it might have been better to follow Zahlbruckner in placing the present family next to the Parmeliaceae, but this disposition is again uncertain, and the Lecanoraceae certainly show stronger affinities with the Parmeliaceae than does the present family.

Members of the family can hardly be confused with any other lichens except certain Dermatocarpons, and careful study of the thallus structure, and more especially of the apothecial characters, will enable one to distinguish readily enough. The general character of the thallus structure and the peculiar disposition of the apothecia are stated in the descriptions of the two genera.

GYROPHORA Ach. Meth. Lich. xxxi, 100. *pl. 2. f. 6.* 1803.

The thallus is foliose and is attached to the substratum by an umbilicus. The margin of the thallus may be entire, but is more usually irregularly incised or torn. A cellular cortex is developed on all sides. The upper cortex is quite thin, and the walls are gelatinized and the cells small. The lower cortex is strongly developed and thickened in order to furnish support for the frequently large thalli supported only at one point. This last feature is unusual in foliose lichens. The lower cortex is, moreover, usually quite uneven in thickness. The medullary tissue is frequently rather thin for so large a thallus. The algal symbiont is *Cystococcus*. The umbilicus is a stem of cortical tissue, supporting the thallus. Or its lower portion is rather a dense bundle of hyphae constituting a large rhizoid. From its base long branching rhizoids extend into the substratum. The prevailing colors of the upper surface are brown,





GYROPHORA HYPERBOREA ACH.

black, and gray. The lower surface is commonly black and is usually roughened or ciliate. In some of the species longitudinal or vertical plates for support replace the rhizoid-like cilia of the lower side of the thallus.

What is commonly considered an apothecium seems rather to be a group of (usually elongated) apothecia closely clustered upon a very short dichotomously branching pedicel. This peculiar structure is very apparent as seen in sections, and even with a hand lens the individual apothecia may usually be plainly distinguished. The apothecia sometimes occur singly. There is a thalloid exciple, usually blackened and devoid of algal cells. The paraphyses are simple or branched. The spores are simple, ellipsoid in form, and pale or hyaline.

The genus is peculiar in many ways, as appears from a study of the above brief description, and is not very closely related to any other genus except *Umbilicaria*, which is commonly included with *Gyrophora*. The two genera show forms with thalli closely resembling *Endocarpon* externally.

Four species of the genus occur in Minnesota, all in the northern portion of the State.

Ours are always found on the igneous or metamorphic rocks. •

Type species *Gyrophora arctica* Ach. op. cit. 106.

KEY TO THE SPECIES.

- Thallus ash-colored above, rhizoid-bearing below..... 3. *G. vellea*.
 Thallus brownish, ashy brownish, or blackish above, with or without rhizoids.
 Thallus clothed below with long, dark rhizoids..... 4. *G. dillenii*.
 Thallus without rhizoids below.
 Thallus more or less pitted and lacunose below..... 1. *G. hyperborea*.
 Thallus reticulated with plates below..... 2. *G. muhlenbergii*.

1. *Gyrophora hyperborea* Ach. Meth. Lich. 104. 1803.

PLATE 31.

Lichen hyperboreus Ach. Vet. Akad. Handl. 15: 89. 1794.

Thallus rounded or irregular in form, the edges more or less jagged and irregular, and sometimes even irregularly lobed, small or middle-sized, 30 to 75 mm. in diameter, papulose-roughened, sometimes sparingly perforate, usually occurring singly but sometimes several thalli more or less imbricated in a cluster; olivaceous or blackish brown, beneath brown to blackish, smooth and more or less pitted and lacunose; apothecia sometimes single but usually in groups, the groups considerably raised and black, more or less rounded and convex, 0.5 to 2.5 mm. in diameter and sometimes containing 100 or over more or less elongated and variously curved apothecia, each apothecium having a black thalloid exciple; hypothecium dark brown; hymenium pale to light brown; paraphyses simple or branched, commonly thickened and brownish toward the apex; asci clavate; spores pale, ellipsoid, 12 to 17 μ long and 5 to 8 μ wide.

Collected only in the extreme northern portion of the State, the only undoubted specimens thus far from the shores of Lake Superior. On rocks.

Found in the United States only in the eastern and western mountains and along the north shore of Lake Superior, but extending northward into arctic regions. Also frequent in northern Europe and Asia.

Umbilicaria hyperborea of the preliminary reports.

EXPLANATION OF PLATE 31.—Plant on high rocks, showing the irregularly lobed and jagged thallus. Natural size.

2. *Gyrophora muhlenbergii* Ach. Lich. Univ. 227. pl. 2. f. 11. 1810.

Thallus usually more or less irregular in outline or even lobed, the margin more or less jagged and irregular, middle-sized or large, 5 to 17.5 cm. in diameter (in some specimens found in the State even exceeding 30 cm. in the longest diameter), sometimes more or less perforate, the smooth upper surface more or less reticulately pitted, brown

to olivaceous-brown or blackish, beneath usually darker, papillose and reticulated with perpendicular and horizontal plates of supporting tissue; apothecia commonly in groups, these raised, black and rounded or irregular in outline, convex, 0.75 to 3 mm. in diameter, the apothecia of a group often more numerous than in the last and of about the same size and form; hypothecium pale-brownish or darker; hymenium pale-brownish or pale; paraphyses simple or rarely branched, the apex commonly thickened and brownish; asci clavate; spores hyaline or pale, oblong, 11 to 13 μ long and 4 to 5 μ wide.

Frequent in the northern portion of the State. On rocks.

Distributed throughout the Northern States and British America. Also known in South America and northern Europe.

Umbilicaria muhlenbergii of the preliminary reports.

3. *Gyrophora vellea* (L.) Ach. Meth. Lich. 109. 1803.

Lichen velleus L. Sp. Pl. 1150. 1753.

Thallus smooth above, variously rounded or irregular in form, the margin usually more or less torn and irregular, rather large-sized, 6.5 to 25 cm. in diameter, considerably thicker and stronger than the two above described, ash-color above, below brown or blackish and clothed with strong rhizoid-like cilia; apothecia commonly in groups, these raised, convex, usually rounded and black, the few seen 1 to 3 mm. in diameter, the individuals frequently much elongated and quite as numerous in the groups as in the last; hypothecium dark brown or rarely paler; hymenium pale or brownish; paraphyses simple or branched, the apices frequently enlarged and brownish; asci cylindrico-clavate; spores hyaline or pale, ellipsoid, 8 to 12 μ long and 5 to 7 μ wide. Seldom fruited.

The plant has about the same distribution in the State as the last, but is by no means so common. On rocks.

In the United States, confined for most part to mountains and to cold shores, but more common throughout British America. Known also in South America and Europe.

Umbilicaria vellea of the preliminary reports.

4. *Gyrophora dillenii* (Tuck.) Arn. Oesterr. Bot. Zeitschr. 1896: 16. 1896.

Umbilicaria dillenii Tuck. Syn. Lich. N. E. 72. 1848.

Thallus smooth above, irregular in form, and margin much as the last, but the thallus brown and varying toward dark or ashy-brown, never ash-colored, beneath also much as the last, but on the whole of a deeper black, 7 to 32.5 cm. in diameter (our largest species); apothecia usually in convex, more or less orbicular groups of the same general form as in the last, the groups sometimes exceeding 4 mm. in diameter; spores ellipsoid, pale or hyaline, 17 to 25 μ long and 9 to 15 μ wide.

The apothecial and spore characters are taken from Tuckerman, our plant being almost always sterile and no well-fruited specimens being at hand.

Distributed throughout the extreme northern portion of the State and extending as far south as Taylors Falls along the eastern boundary. On rocks.

A strictly North American plant distributed throughout the Atlantic States, though confined to the mountains toward the south. More common throughout the eastern portion of British America.

Umbilicaria dillenii of the preliminary reports.

UMBILICARIA Hoffm. Descr. Pl. Crypt. 1: 7. pl. 2. f. 1-4. 1790.

The thallus is foliose and, like that of *Gyrophora*, is attached to the substratum by an umbilicus. The lower cortex is thickened as in *Gyrophora*, for the same purpose, that of support, and the upper cortex is likewise thin. In our species at least, the mechanical plates are wanting and seem to be replaced by the rings of tissue about the pustules. The algal symbiont is *Cystococcus*.

As in *Gyrophora*, the apothecia frequently occur in groups, and each group is frequently considered a single apothecium. The individual apothecia are usually rounded instead of elongate. The spores are many-celled and muriform, commonly brown, though they may be pale. A single spore usually occupies each ascus, though two sometimes occur together.

The genus has a single representative within the State.

Ours and the other American species occur on rocks.

Type species *Umbilicaria exasperata* (Gunn.) Hoffm. loc. cit.

1. *Umbilicaria pustulata* (L.) Hoffm. Descr. Pl. Crypt. 2: 13. pl. 28. f. 1-2. pl. 29. f. 4. 1794.

Lichen pustulatus L. Sp. Pl. 1150. 1753.

Thallus rounded or irregular in form, the edges more or less irregular and sometimes irregularly lobed, usually of middle size, 3 to 15 cm. in diameter; prominently papulose or pustulate, occurring singly, brown or brownish ash-colored, sometimes more or less powdery, beneath grayish to brownish, granulate, lacunosely pitted; apothecia sometimes single but more commonly in groups, these considerably raised, black and more or less rounded, 0.5 to 2 mm. in diameter, the largest clusters seldom containing more than 12 to 15 apothecia; the individual apothecium usually rounded and concave and when alone reaching 0.5 mm. in diameter, or even 1 mm. in foreign specimens; hypothecium pale brownish to brown; hymenium brownish; paraphyses frequently branched both near the apex and farther back, the apex commonly thickened and brownish; asci broadly-clavate; spores ellipsoid or oblong-ellipsoid, brown or sometimes pale, 48 to 70 μ long and 22 to 38 μ wide.

The subspecies *Umbilicaria pustulata papulosa* (Ach.) Tuck.^a has been recorded for the State, but there are scarcely two distinct forms in Minnesota. Possibly ours is all nearer the subspecies; it surely is so in color, Tuckerman giving ashy gray as the color of the species.

Found throughout the extreme northern portion of the State, but rare. On rocks.

Distributed throughout the eastern side of North America, especially in the mountains. Also in Texas and New Mexico. Known in all of the grand divisions except Australia.

Family LECANORACEAE.

The family as represented in our flora consists of the three genera, *Acarospora*, *Lecanora*, and *Haematomma*. The family thus limited seems natural enough, but is closely related to the Parmeliaceae, the close relationship appearing most plainly in the few foliose Lecanoras, such as *L. rubina* and *L. muralis*. However, even in these two species, the thallus is closely adnate and scarcely more than subfoliose, while in the Parmeliaceae the thalli are always plainly foliose or fruticose.

Thus it appears that the present family is most closely related to the Parmeliaceae, and Schneider has seen fit to unite the two families. But there are other relationships of the Lecanoraceae, as already mentioned, viz, with the Baeomycetaceae through *Icmadophila* and with certain Lecideaceae which show some indication of a thalloid exciple.

In the present family the thallus is commonly crustose, but a few of the species of *Lecanora* possess subfoliose thalli. The algal symbiont is commonly *Cystococcus*, but *Pleurococcus* seems to occur instead in the *Acarosporas*. The apothecia vary as to position from sessile to immersed, and the thalloid exciple is plainly evident and commonly persistent in all superficial apothecia. The spores are always hyaline and never muriform, but they vary considerably within these limitations.

The family is large, the genus *Lecanora* being one of the largest in our flora.

^a Syn. Lich. N. E. 70. 1848.

ACAROSPORA Mass. Ric. Lich. 27. f. 43-46. 1852.

PLATE 32.

The thallus varies from typically crustose to squamulose or subfoliose forms and is always closely adnate. In most of the species, and in all of ours, there is a good cellular cortex above. The algal and medullary layers are also usually more or less differentiated. The lower portion is scarcely different from the so-called medullary, and, indeed, the whole thallus is frequently more or less distinctly cellular throughout. The algal symbiont is *Pleurococcus*. The attaching organs are rhizoidal hyphæ. The thallus varies greatly in color, white, yellow, greenish, and brown, and even blackish examples occurring.

The apothecia vary considerably in size and appearance, but are always more or less immersed in the thallus, at least in our species. The thalloid exciple is rather poorly developed and tends to disappear in all of our species. The hypothecium is pale and the hymenium of the same color or darker above. The asci vary considerably in form, and the paraphyses are simple or rarely branched. The spores are hyaline, minute, and very numerous in the asci.

The genus is frequently placed with *Lecanora*, but it seems evident enough that species showing such pronounced spore differences should not be referred to that genus. In structure the thallus resembles that of some of the *Lecanoras*, and indeed the cells of the upper cortex are much better differentiated and more distinct in the present genus. However, the spores make it seem possible that there is a close relation between the present genus and *Biatorella*. But the present genus differs from *Biatorella* in having better developed thalli with good upper cortex and in making more or less of a showing of a thalloid exciple. Perhaps the thalloid and excipial development should not count for more than the spores in classification, and it may not, consequently, be unreasonable to suppose that the present genus is more closely related to *Biatorella* than to *Lecanora*.

The genus is not large and is represented in our flora by only four species and subspecies. All occur on rocks, though one has been found on old wood also.

Type species *Acarospora schleicheri* (Ach.) Mass. loc. cit.

EXPLANATION OF PLATE 32.—Fig. 1, *a*, the apothecia; *b*, the thallus on the substratum. Fig. 2, a single apothecium and a small portion of the thallus. Fig. 3, a section of an apothecium and part of the thallus; *a*, the hymenium; *b*, the hypothecium; *c*, the cellular medullary layer. Fig. 4, a section of the thallus; *a*, the upper cortex; *b*, the algal layer; *c*, the cellular medullary layer; *d*, the hyphal rhizoids. Fig. 5, paraphyses and an ascus. Fig. 6, free, simple, and minute spores. Fig. 7, algal cells (*Pleurococcus*), *a*, as they occur in the thallus; *b*, normal size. Fig. 1, natural size; fig. 2, enlarged about 35 diameters; fig. 3, enlarged 400 diameters; fig. 4, enlarged 300 diameters; figs. 5 and 6, enlarged 650 diameters; fig. 7, enlarged: *a*, 650 diameters; *b*, 500 diameters. From Schneider.

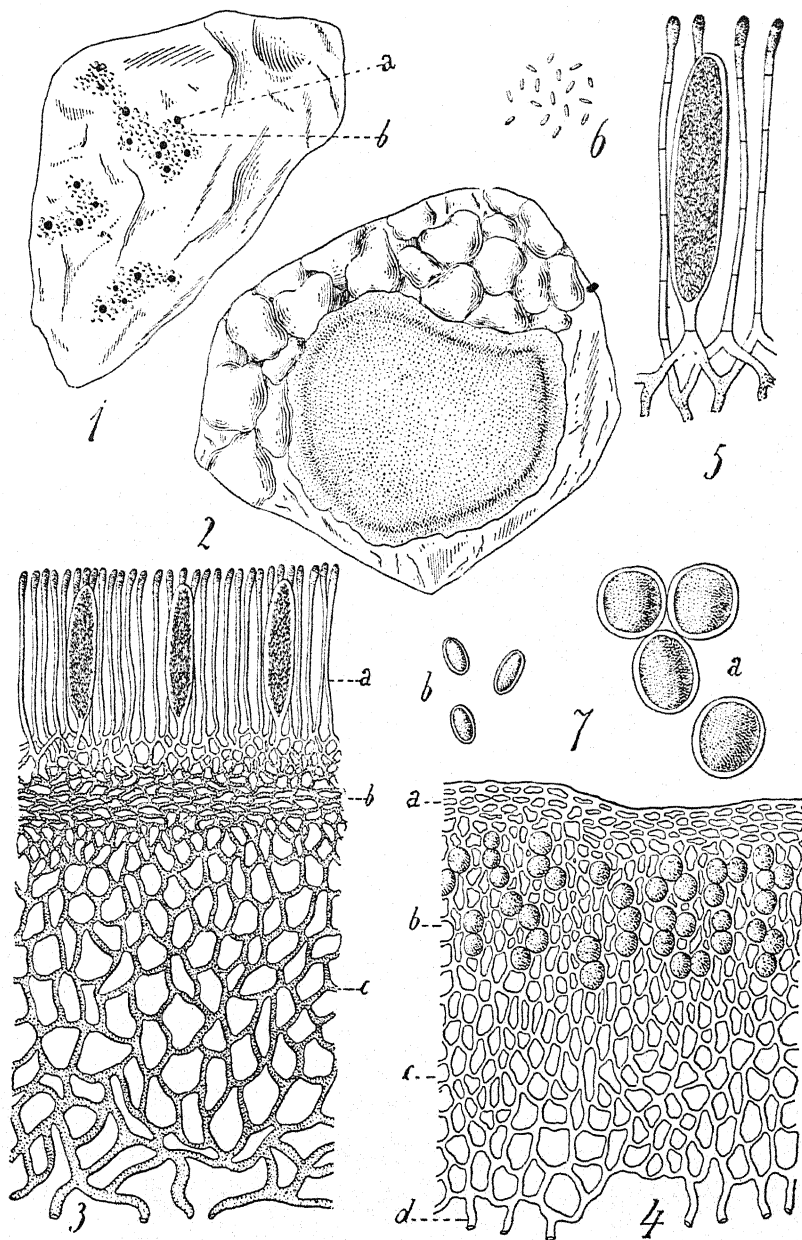
KEY TO THE SPECIES.

- | | | |
|---|-----|----------------------------------|
| Thallus lemon-yellow..... | 1. | <i>A. xanthophana</i> . |
| Thallus yellowish brown to chestnut, or rarely ashy white. | | |
| Squamules scattered and usually plainly lobed; thallus yellowish brown to chestnut..... | 2b. | <i>A. cervina fuscata</i> . |
| Squamules usually compacted into an areolate crust, not conspicuously lobed. | | |
| Thallus yellowish brown to chestnut..... | 2. | <i>A. cervina</i> . |
| Thallus ashy white..... | 2a. | <i>A. cervina cinereo-alba</i> . |

1. *Acarospora xanthophana* (Nyl.) Fink.

Lecanora xanthophana Nyl. Ann. Sci. Nat. Bot. IV. 15: 379. 1862.

Thallus composed of peltate or round-lobulate squamules, which are usually compacted, except about the margin of the thallus, into an angulate-areolate crust, the



AN ACAROSPORA.

areoles or squamules flat or rarely more or less convex and of moderate size, 0.3 to 2 mm. across, lemon-yellow, the upper cortex present, distinctly cellular, as is the whole thallus, the squamules sometimes scattered; apothecia small or minute, 0.2 to 0.5 μ in diameter (said to be sometimes larger), immersed, the disk flat or somewhat concave, frequently somewhat irregular and reddish brown or rarely blackish, the thalloid exciple usually evident and entire; hypothecium pale; hymenium of same color, or darker above; paraphyses simple or rarely branched, frequently somewhat enlarged and brownish toward the apex; asci clavate, cylindrico-clavate, or somewhat irregular; spores ovoid, 3 to 3.5 μ long and 1.5 to 2 μ wide.

The plant has been collected in such widely separate portions of the State as Minneapolis, Battle Lake, and several localities in the southwestern part. On rocks other than calcareous.

Generally distributed over the United States and northward into British America. Known also in South America and Africa.

Lecanora xanthophana of the preliminary reports.

2. *Acarospora cervina* (Wahl.) Koerb. Syst. Lich. 154. 1855.

Lichen cervinus Wahl. Fl. Lapp. 421. 1812.

Thallus composed of subpetate or crenate-lobate squamules, which are closely adnate and may be scattered or more commonly compacted into an areolate crust, the areoles or squamules rather smaller than those of the last, commonly flat and rarely imbricate, yellowish brown (cervine) to dark chestnut; microscopic structure as in the last; apothecia much as in the last, but rather larger and sometimes becoming adnate, the thalloid exciple perhaps disappearing more often; hypothecium pale; hymenium of same colors or brownish above; paraphyses slender, simple or rarely branched, usually slightly enlarged and brownish toward the apex; asci ventricose or cylindrico-clavate; spores oblong to subspherical, 3 to 5 μ long and 1 to 2 μ wide in the oblong forms.

Generally distributed over the State. On rocks other than calcareous.

Throughout North America, except the Southern States and southward. Found also in Europe and Africa.

Lecanora cervina (Pers.) Nyl. of the preliminary reports.

2a. *Acarospora cervina cinereoalba* Fink, Minn. Bot. Stud. 2: 319. 1899.

Thallus ashy or ashy-white. Otherwise as the species.

Collected at Mankato and at Granite Falls. On granite with the usual form of the species.

A North American form not known elsewhere.

Lecanora cervina cinereoalba of the preliminary reports.

2b. *Acarospora cervina fuscata* (Schr.) Fink.

Lichen fuscatus Schrad. Spic. Fl. Germ. 83. 1794.

Thallus inclined to more squamulose and lobed conditions, the squamules rather larger and often scattered; apothecia rather smaller and sometimes punctiform; spores said to be larger (Nylander).

Usually regarded as a distinct species.

No doubt generally distributed over the State, but very difficult to distinguish. On rocks.

North American distribution much as that of the species. Known also in South America, Europe, and Africa.

Lecanora fuscata and subspecies *rufescens* of the preliminary reports.

LECANORA Ach. Lich. Univ. 77, 344. pl. 7. f. 3-7. 1810.

The thallus varies from foliose or subfoliose to strictly crustose forms, the latter being the more common and representative thalli of the genus. In the best developed thalli the whole structure is nearly or quite as closely adnate as in the more

typically crustose species. Some lichenists, however, admit to the genus plants having fruticose thalli. In our foliose species there is a well-developed upper cortex, which is much gelatinized and seems to be most commonly composed of hyphæ rather than pseudocellular. In these the lower cortex is similar but commonly thinner, or sometimes scarcely at all developed. In these foliose species the algal and medullary layers are also well developed, while rhizoids are few or entirely absent. The better-developed crustose forms show some suggestion of an upper cortex and algal and medullary layers, but the great majority of them do not; in the latter there are found the simple hyphal rhizoids as attaching organs. *Cystococcus* is the algal symbiont.

The apothecia are commonly of medium size, usually sessile, though adnate and immersed forms occur. The thalloid exciple is commonly somewhat raised, though it may disappear entirely, leaving a biatoroid apothecium. The exciple is most commonly entire or crenate and the disk flat or slightly convex. The hypothecium is pale or only slightly colored, and the hymenium is of the same color, or darker above. The asci are clavate, as a rule, and the paraphyses commonly simple, though compound forms may doubtless be found in any of the species. The spores are simple, but vary greatly as to size and form.

The foliose species are sometimes placed in another genus, but there is a gradual transition to the crustose forms, which may be represented to some extent, at least externally, in the most foliose species, and for this reason it has not seemed best to attempt a division. As to thallus structure, the genus is as a whole most closely related to *Haematomma* and *Acarospora*, and only less closely with some of the better-developed *Lecideas*. Also, there is a not very remote relationship between the present genus and the one last named as to spores and apothecial structure, transitional forms between thalloid and lecideoid exciples occurring in both genera. *Lecanora* shows also affinities with *Parmelia*.

Some forty forms occur in the State. Mostly on trees and rocks.

Type species *Lecanora tartarea* (L.) Ach. loc. cit.

KEY TO THE SPECIES.

Section I. Thallus usually lobed at the circumference (as also in two species of Section II).

Thallus rather thick and often scattered, greenish straw-colored.

- | | |
|--|-------------------------------------|
| Apothecia pale yellow to yellowish brown..... | 1. <i>L. rubina</i> |
| Apothecia of the same color as the thallus or pale brown.... | 1a. <i>L. rubina heteromorpha</i> . |

Thallus thinner, smaller, and more compact.

Thallus some other color than sea green.

- | | |
|---|------------------------------------|
| Thallus light-colored and sometimes white-powdery, often breaking away at the center or one side..... | 2b. <i>L. muralis versicolor</i> . |
|---|------------------------------------|

- | | |
|--|-----------------------------------|
| Thallus becoming yellowish brown or reddish brown; the lobes short and often black-margined..... | 2d. <i>L. muralis diffracta</i> . |
|--|-----------------------------------|

Thallus sea-green.

- | | |
|-----------------------------------|----------------------------------|
| Thallus lobes much flattened..... | 2a. <i>L. muralis saxicola</i> . |
|-----------------------------------|----------------------------------|

Thallus lobes not so much flattened.

- | | |
|--|------------------------------------|
| Thallus lobes somewhat elongated..... | 2. <i>L. muralis</i> . |
| Thallus lobes much elongated and flexuous..... | 2c. <i>L. muralis garovaglii</i> . |

Section II. Thallus not lobed (except in nos. 5 and 16).

Spores often more than $20\ \mu$ in length.Spores reaching $50\ \mu$ in length.Thallus thick and rough..... 15. *L. tartarea*.

Thallus thinner.

Thallus smoothish; apothecia large, flesh-colored or white-pruinose..... 14. *L. pallescens*.Thallus verrucose, chinky or subareolate; apothecia small or minute, black..... 17. *L. mutabilis*.Spores not reaching $50\ \mu$ in length.

Apothecia immersed, or becoming adnate.

Apothecia always becoming adnate, disk black, exciple entire..... 18b. *L. cinerea gibbosa*.

Apothecia sometimes becoming adnate.

Disk light brown or darker, commonly white-pruinose..... 19. *L. calcarea*.Disk of same color as above, not pruinose, but frequently punctiform..... 19a. *L. calcarea contorta*.

Apothecia always immersed.

Thallus ashy to brownish.

Thallus thick and becoming areolate; disk black, medium-sized..... 18. *L. cinerea*.Thallus thinner, never becoming areolate; disk usually minute or irregular..... 18a. *L. cinerea laevata*.

Thallus finally darker-colored.

Thallus ashy to olivaceous; disk reddish or brownish; plant found on rocks frequently wet..... 20. *L. lacustris*.Thallus blackish-olivaceous..... 18c. *L. cinerea microspora*.Spores never surpassing $20\ \mu$ in length.

Apothecia always sessile, or varying in position from sessile to adnate.

Apothecia always sessile; disk dark; exciple entire or subcrenulate; margin of the thallus usually lobed.... 5. *L. frustulosa*.

Apothecia either sessile or adnate.

Disk whitish buff or more or less whitish-pruinose.

Exciple entire and usually regular..... 3. *L. pallida*.Exciple angulate and variously irregular..... 3a. *L. pallida angulosa*.

Disk light brown to black.

Thallus quite thick and more or less imbricate-lobed. 16. *L. melanaspis*.

Thallus not lobed.

Thallus thick and rough, areolate or verrucose.

Exciple persistent.

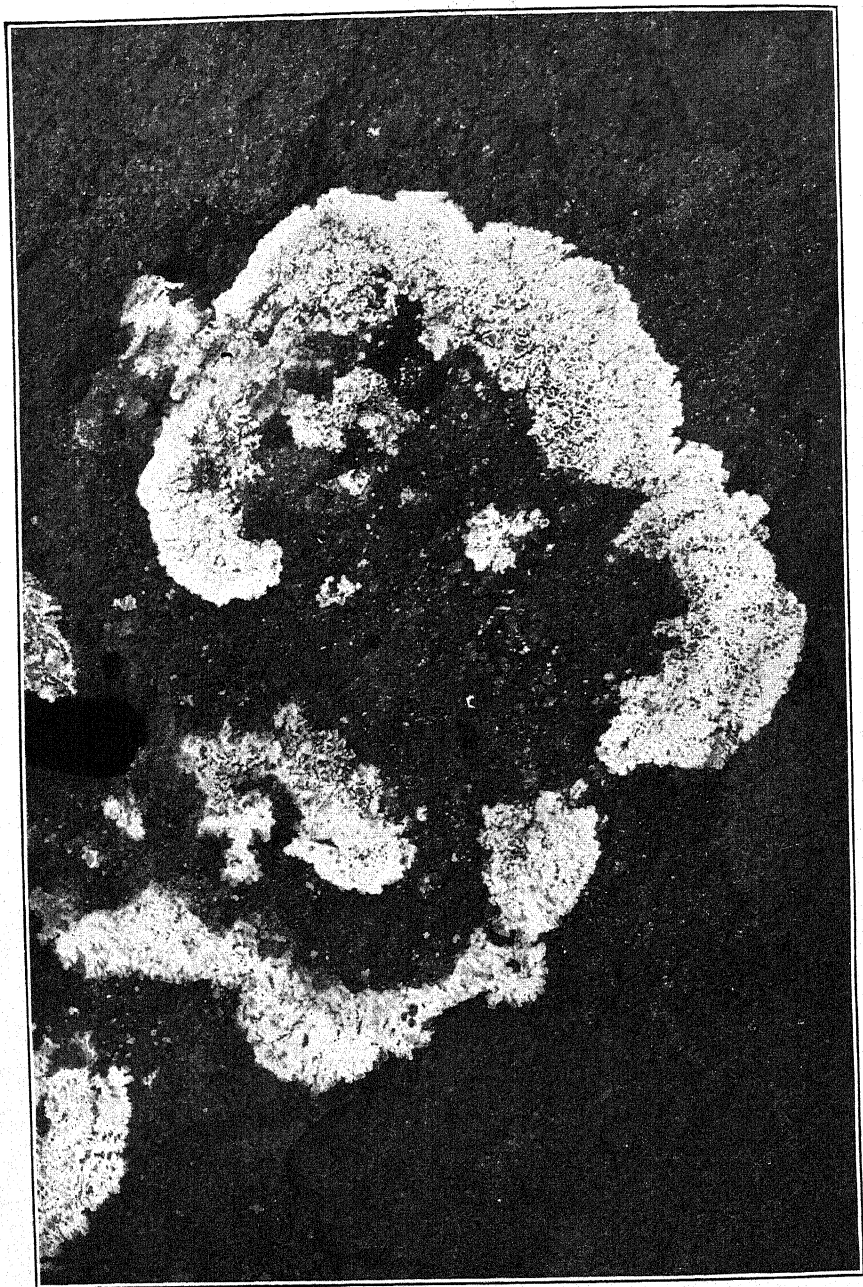
Exciple often flexuous, entire, or crenate..... 7a. *L. subfusca allophana*.Exciple scarcely ever flexuous, entire, or crenate..... 7. *L. subfusca*.Exciple frequently disappearing..... 7b. *L. subfusca campestris*.

- Thallus not so thick, sometimes granulose.
 Thallus granulose, or becoming verrucose.
 Thallus granulose and sorediate..... 7g. *L. subfusca sorediifera*.
 Thallus granulose, becoming verrucose..... 7c. *L. subfusca hypnorum*.
 Thallus smooth or chinky.
 Exciple entire.
 Apothecia small, usually brown..... 7d. *L. subfusca argentata*.
 Apothecia small, usually black..... 7e. *L. subfusca coilocarpa*.
 Exciple subentire; apothecia flesh-colored or pale brown, small or minute..... 7f. *L. subfusca distans*.
 Apothecia always \propto dnate, or varying in position from adnate to immersed.
 Apothecia always adnate.
 Exciple usually crenate or crenulate.
 Disk gray-pruinose..... 8. *L. hageni*.
 Disk not gray-pruinose.
 Disk brown to blackish; spores sometimes 2-celled..... 13. *L. erysibe*.
 Disk yellowish brown to olivaceous..... 9. *L. dispersa*.
 Exciple scarcely ever plainly crenate or crenulate.
 Exciple entire, flexuous, or rarely subcrenulate.
 Exciple becoming flexuous or rarely disappearing, disk dark grayish or yellowish..... 12. *L. polytropa*.
 Exciple persistent, entire or subentire; disk flesh-colored to light brown..... 10. *L. sambuci*.
 Exciple irregular or disappearing; disk flesh-colored to brownish..... 21. *L. subepulotica*.
 Apothecia adnate or more or less immersed.
 Disk always black, or becoming black.
 Disk always black; exciple usually entire..... 4. *L. atra*.
 Disk becoming black.
 Disk more or less pruinose.
 Disk at first flesh-colored..... 6. *L. sordida*.
 Disk at first reddish-olivaceous..... 11b. *L. varia saepincola*.
 Disk not pruinose, flesh-colored to blackish; exciple entire or disappearing..... 11a. *L. varia symmetrica*.
 Disk never black.
 Disk flesh-colored to yellowish buff; exciple entire or crenulate..... 11. *L. varia*.
 Disk dark grayish or yellowish; exciple becoming flexuous and disappearing..... 12a. *L. polytropa me-laena*.

1. *Lecanora rubina* (Lam. & DC.) Ach. Lich. Univ. 412. 1810.

Lichen rubinus Lam. & DC. Fl. Fr. ed. 3. 1: 77. 1778.

Thallus commonly closely adnate and subfoliose but rarely plainly foliose, sub-monophyllous and attached by an umbilicus; the former crenate more or less round-lobed, irregular or suborbicular, 15 to 30 mm. in diameter, the lobes sometimes becoming elongated, frequently imbricated or more often closely aggregated into an appar-



LECANORA MURALIS VERSICOLOR (PERS.) TUCK.

ently areolate crust, this sometimes radious at the circumference; or rarely reduced to scattered, closely adnate, flattened or hemispherical squamules, greenish straw-colored above, beneath commonly black; apothecia scattered or rarely clustered, middle-sized or large, 1.5 to 5 mm. in diameter, sessile or adnate, pale yellow to reddish brown, the thalloid margin thin, flexuous, and sometimes disappearing, the disk usually flat, convex or variously irregular; hypothecium pale or pale yellowish; hymenium pale below and commonly somewhat colored above; paraphyses simple or rarely branched, usually enlarged and colored toward the apex; asci clavate; spores ellipsoid, 7 to 15 μ long and 4.5 to 8 μ wide.

Generally distributed over the State. On rocks other than calcareous.

The plant is generally distributed in North America, but mostly confined to the mountains southward. Known also in South America, Europe, and Asia.

1a. *Lecanora rubina heteromorpha* Ach. Lich. Univ. 412. 1810.

Thallus somewhat chinky or wrinkled, in ours less inclined to distinctly lobed conditions; apothecia of the same color as the thallus or becoming pale brown.

Probably as widely distributed in the State as the species, though not so common and less often observed. Habitat the same as above.

Elsewhere in North America from Texas, Oregon, and Iowa. Known also in Europe.

2. *Lecanora muralis* (Schreb.) Tuck. Gen. Lich. 113. 1872.

Lichen muralis Schreb. Spic. Fl. Lips. 130. 1771.

Thallus closely adnate, subfoliose, lobed and the lobes usually somewhat elongated and sinuately divided toward the margins, the central portions commonly more or less crenate-scaly or areolate, on the whole thinner and more closely attached than that of the last, and likewise frequently tending to pass into poorly developed conditions, the best developed forms usually suborbicular, 10 to 60 mm. in diameter; commonly sea-green, the cortical layers composed of closely packed hyphae, or the upper perhaps sometimes pseudocellular, the lower very thin; apothecia small to middle-sized, 0.65 to 2 mm. in diameter, adnate or rarely somewhat immersed, the disk flat or somewhat concave, pale yellowish to tawny brown, the thalloid exciple entire, flexuous or crenate; hypothecium pale; hymenium pale below, and frequently somewhat brownish above; paraphyses commonly simple, frequently enlarged and brownish toward the apex; asci clavate; spores ellipsoid, 9 to 15 μ long and 4.5 to 7 μ wide.

Tuckerman's view has been followed in disposing of the present species and its subspecies. Europeans commonly group the subspecies about the next form.

The plant is generally distributed over the State, usually as one of the subspecies below. On rocks.

Distributed throughout North America in one form or another. Known also in all of the grand divisions, most commonly as the first subspecies below.

2a. *Lecanora muralis saxicola* (Poll.) Tuck. Syn. N. A. Lich. 1: 184. 1882.

Lichen saxicola Poll. Hist. Pl. Palat. 3: 225. 1777.

Form with the thallus lobes much flattened, and normally colored. Our most common subspecies.

Generally distributed over the State. On rocks other than calcareous.

The most widely distributed North American form. Known also in all of the grand divisions.

2b. *Lecanora muralis versicolor* (Pers.) Tuck. Syn. N. A. Lich. 1: 185. 1882.

PLATE 33.

Lichen versicolor Pers. Ann. Bot. Usteri 7: 24. 1794.

Thallus smaller and frequently breaking away at one side or in the center, frequently several thalli closely packed together and even overlapping more or less,

lighter-colored and sometimes more or less white-powdery; apothecia smaller, more inclined to immersed conditions, the exciple usually entire.

Collected at Mankato and at Battle Lake. On limestones. No doubt occurs on the same rocks in other portions of the State, especially in the southeastern portion.

Elsewhere in North America in Iowa, Nebraska, Missouri, Kansas, and Newfoundland. Known also in Europe.

EXPLANATION OF PLATE 33.—Plant on rocks, showing the fairy ring formation characteristic of this subspecies. Natural size.

2c. *Lecanora muralis garovaglii* (Koerb.) Tuck. Syn. N. A. Lich. 1: 184. 1882.

Placodium garovaglii Koerb. Par. Lich. 54. 1865.

Thallus lobes elongated, flexuous, convex, plicate-radious, normally colored.

Collected at Koochiching on the northern boundry of the State. On rocks.

Known elsewhere in North America in Nebraska, Nevada, and Newfoundland. Found also in Europe and Africa.

2d. *Lecanora muralis diffracta* (Ach.) Tuck. Syn. N. A. Lich. 1: 184. 1882.

Lichen diffractus Ach. Lich. Suec. 63. 1798.

Thallus darker, usually yellowish brown or reddish brown, central areoles scattered more or less and frequently black-margined, the lobes of the margin short.

Collected at Grand Portage, on Mount Josephine. On rocks. The material referred to here is uncertain.

Elsewhere in North America in California. Known also in Europe.

3. *Lecanora pallida* (Schreb.) Schaer. Enum. Lich. Eur. 78. 1850.

Lichen pallidus Schreb. Spic. Fl. Lips. 133. 1771.

Thallus crustose, neither lobed nor in any degree foliose, but closely adnate and, like the other crustose species, attached by hyphal rhizoids, usually thin and smooth, but becoming thicker and chinky or somewhat verrucose, whitish or pale cream-colored and darkening, cortical layer scarcely developed, usually somewhat irregular in form and 5.5 to 10 cm. across, or even more widely spread; apothecia sessile or more commonly adnate, small to middle-sized, 0.7 to 3 mm. in diameter, the disk whitish buff and white-pruinose, flat, with a thick and entire exciple, or becoming convex and sometimes irregular, and the margin rarely disappearing or more commonly becoming flexuous; hypothecium pale; hymenium pale throughout or somewhat brownish above; paraphyses commonly simple and more or less gelatinized, frequently enlarged and brownish above; asci clavate; spores ellipsoid, 7 to 15 μ long and 5 to 8 μ wide.

Thus far collected only in the northern portion of the State, but the plant occurs in northern Iowa and doubtless also farther south in Minnesota. On trees.

Generally distributed throughout North America. Known in all of the grand divisions.

3a. *Lecanora pallida angulosa* (Schreb.) Koerb. Syst. Lich. 145. 1855.

Lichen angulosus Schreb. Spic. Fl. Lips. 136. 1771.

Apothecia becoming crowded with angulate and variously irregular exciple, the disk rather more darkly subpruinose.

In our single specimen the exciple is persistent and the thallus rather thick and subverrucose or chinky-subareolate. The specimen was collected at Duluth by Anna M. Kimball and has not otherwise been reported from the State. On trees.

Scarcely referred to in North America lists except in a general way in Tuckerman's Synopsis, but no doubt quite widely distributed. Known also in Europe and Africa.

4. *Lecanora atra* (Huds.) Ach. Lich. Univ. 344. 1810.

Lichen ater Huds. Fl. Angl. 445. 1762.

Thallus crustose and of moderate thickness, composed of granules which usually run together into a smoothish or more commonly verrucose or areolate crust, occurring

in suborbicular patches, 2 to 6.5 cm. in diameter or more commonly irregularly and more widely spread over the substratum, sea-green varying toward whitish ash-color, scarcely corticate; apothecia small to middle-sized, 0.9 to 2 mm. in diameter, adnate or more or less immersed, the disk very black, flat or somewhat convex, the exciple entire or rarely flexuous or crenulate, very rarely disappearing, and occasionally blackening; hypothecium and hymenium brown or blackish brown, or appearing black under a hand lens; paraphyses somewhat coherent, but apparently simple, usually somewhat colored throughout, and darker and thicker toward the apex; asci clavate; spores ellipsoid, 10 to 15 μ long and 5 to 7 μ wide.

The plant is difficult to distinguish from the next species and from *Lecanora sub-usca coilocarpa*, but the dark hymenium and hypothecium serve to differentiate it.

Collected at Taylors Falls. On the igneous rocks.

Generally distributed throughout North America. Known also in all of the grand divisions.

5. *Lecanora frustulosa* (Dicks.) Ach. Lich. Univ. 405. 1810.

Lichen frustulosus Dicks. Pl. Crypt. Brit. 3: 13, pl. 8, f. 1. 1793.

Thallus crustose and rather thick, the central portions areolate or verrucose-areolate, the areoles or verrucae much raised and irregular (globose-frustulose) or even subsquamulose, the margin usually more plainly squamulose and subfoliose, commonly suborbicular, covering considerable areas of the substratum, usually 2.5 to 10 cm. in diameter, the areoles somewhat scattered, or more commonly crowded and subimbricate; sea-green varying toward ashy or yellowish, sometimes showing a cellular cortex, and the algal and medullary layers frequently quite distinct; apothecia small to middle-sized, 1 to 2 mm. in diameter, sessile, the disk flat or somewhat convex, reddish brown to black, the exciple persistent or rarely disappearing, entire or subcrenate; hypothecium pale; hymenium pale below and brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores ellipsoid, 9 to 15 μ long and 5 to 7.5 μ wide.

Distributed throughout the northern portion of the State and also found on the granitic rock exposures of the Minnesota River valley, there collected at Redwood Falls and at Granite Falls. On rocks other than calcareous.

Elsewhere in North America in Greenland, New England, South Dakota, Colorado, and California. Known also in Europe and Asia.

6. *Lecanora sordida* (Pers.) Th. Fr. Nov. Act. Soc. Sci. Ups. III. 3: 215. 1861.

Lichen sordidus Pers. Ann. Bot. Usteri 7: 26. 1794.

Thallus crustose, rarely unbroken, but more commonly chinky or areolate, rather smooth or the areoles somewhat raised and irregular, usually widely and irregularly spread over the substratum, the margins sometimes obscurely subsquamulose, scarcely corticate, commonly whitish varying toward gray or rarely brownish; apothecia usually small, 0.75 to 1.5 mm. in diameter, adnate or more or less immersed, the disk flat or convex, flesh-colored to black but whitish-pruinose, the exciple entire and rarely disappearing; hypothecium pale; hymenium pale beneath and commonly more or less brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores ellipsoid, 7 to 14 μ long and 5 to 7 μ wide.

Collected in the northeastern portion of the State at Grand Portage, at South Fowl Lake, and in the Misquah Hills. On high bluffs.

Distribution in North America essentially the same as that of the last species above, but the present species has been met in New York and at several places in British America. Known also in all of the grand divisions except Australia.

7. *Lecanora subfusca* (L.) Ach. Lich. Univ. 393. pl. 7. f. 6. 1810.

FIGURE 14.

Lichen subfuscus L. Sp. Pl. 1142. 1753.

Thallus crustose, rather smooth, or becoming chinky or verrucose-areolate, usually of moderate thickness, but rarely thin, with the granules somewhat scattered, occurring in suborbicular patches, from 1.5 cm. upward in diameter, or irregular and frequently widely spread over the substratum, sea-green varying to ashy or whitish, without other cortical structure than a gelatinized and often structureless mass of hyphæ; apothecia

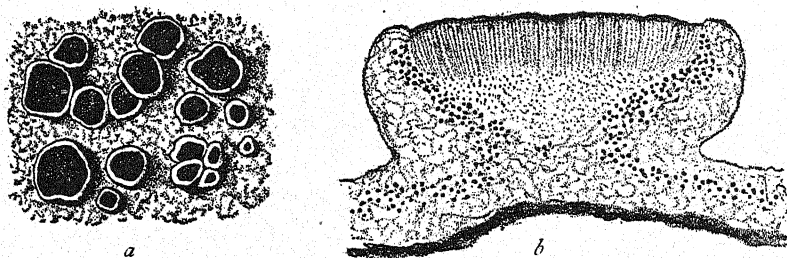


FIG. 14.—*Lecanora subfusca*. a, Thallus with several apothecia; b, a section of an apothecium to show the thalloid exciple, the hymenium and the hypothecium; a, Enlarged 3 diameters; b, 60 diameters. From Reinke.

small to middle-sized, sessile or adnate, 0.5 to 2 mm. in diameter, the disk flat to somewhat convex, light brown to black in color, the exciple entire to crenate and always persistent; hypothecium pale; hymenium pale below and usually pale brownish above; paraphyses simple or rarely branched, sometimes enlarged and brownish toward the apex; asci variously clavate; spores ellipsoid, 9 to 20 μ long and 6 to 10 μ wide.

Generally distributed over the State, as are some of the subspecies given below. On trees or dead wood, or rarely on rocks.

Known throughout North America. Found also in all of the grand divisions.

7a. *Lecanora subfusca allophana* Ach. Lich. Univ. 395. 1810.

Thallus rather thick, rough or granulate-verrucose; apothecia reaching the full size of the species, the disk reddish brown to blackish, the exciple entire, flexuous, or crenate; spores reaching full size for the species.

In this and the other subspecies we have followed Tuckerman.

Distributed throughout the northern portion of the State. On cedars in swamps.

Though the subspecies is not recorded for a large number of North American localities, it is no doubt widely distributed. Known also in South America, Europe, and Africa.

7b. *Lecanora subfusca campestris* Schaer. in Rabenh. Lich. Exsicc. 691. 1860.

Thallus becoming thick and roughened; apothecia finally and often irregularly convex and the exciple frequently disappearing, wholly or in part.

Collected at Minneapolis and at Granite Falls; not previously reported from the State. On rocks.

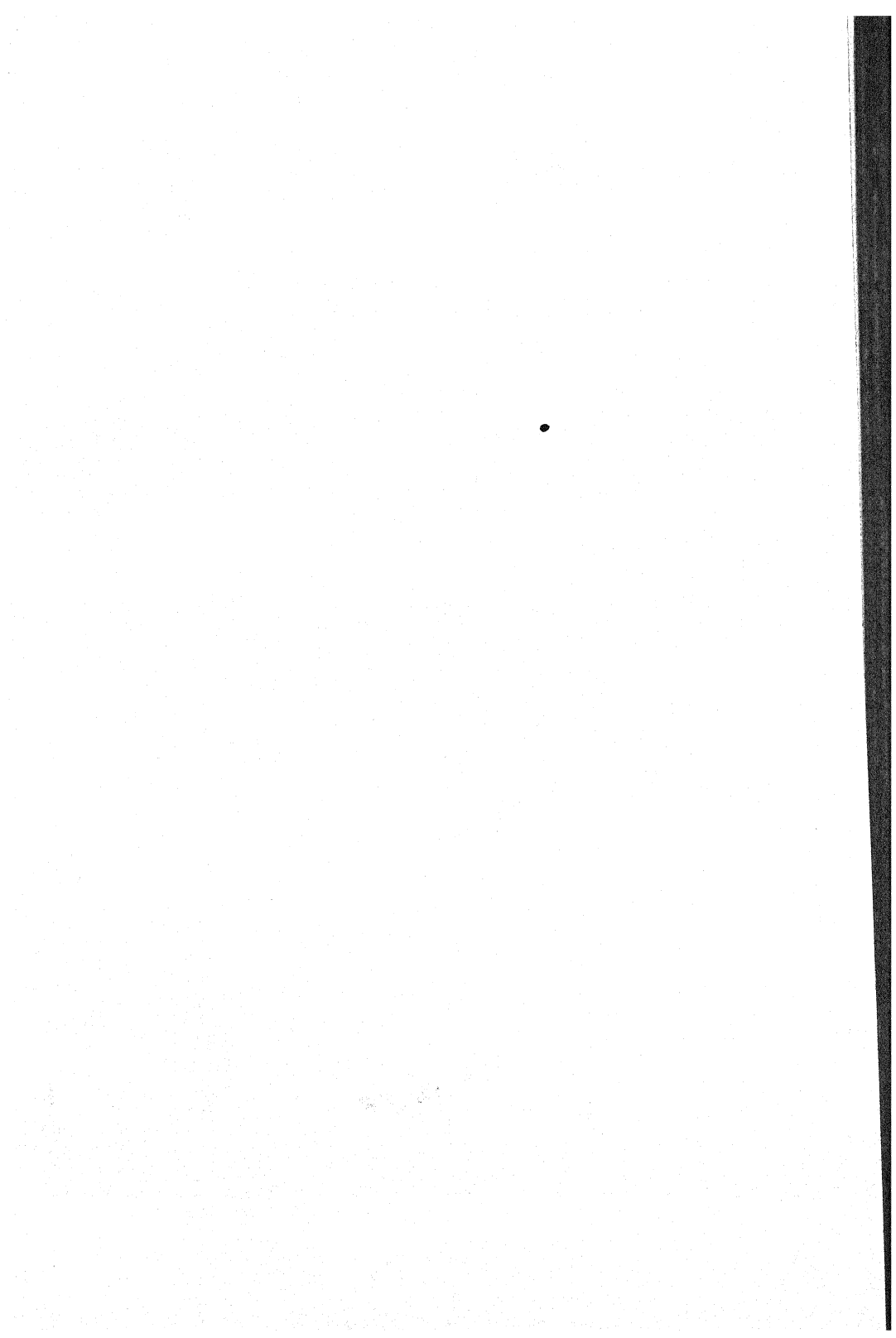
Elsewhere in North America in California. Known also in Europe, Asia, Africa, and New Zealand.

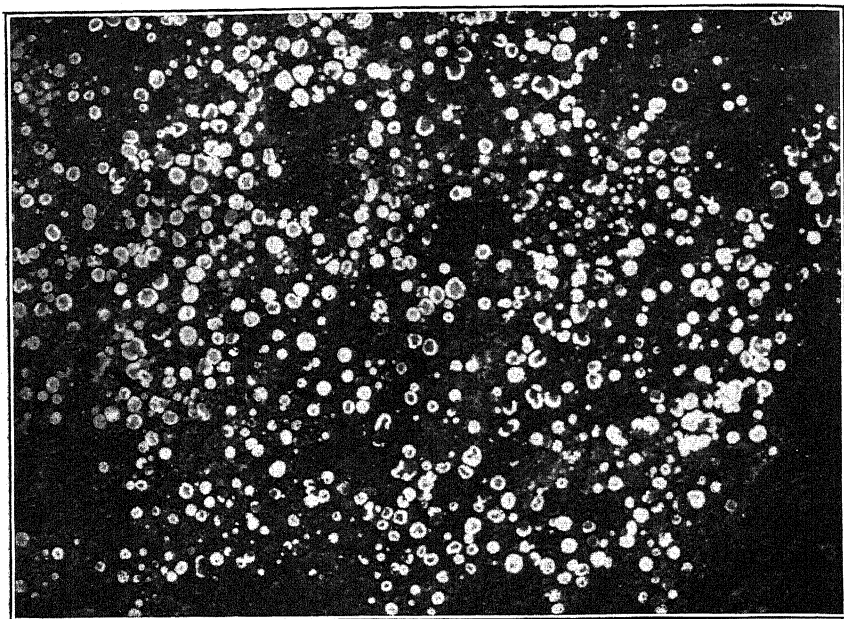
7c. *Lecanora subfusca hypnorum* (Wulf.) Schaer. Enum. Lich. Eur. 75. 1850.

Lichen hypnorum Wulf. in Jacq. Coll. Bot. 4: 233. pl. 7. f. 2. 1790.

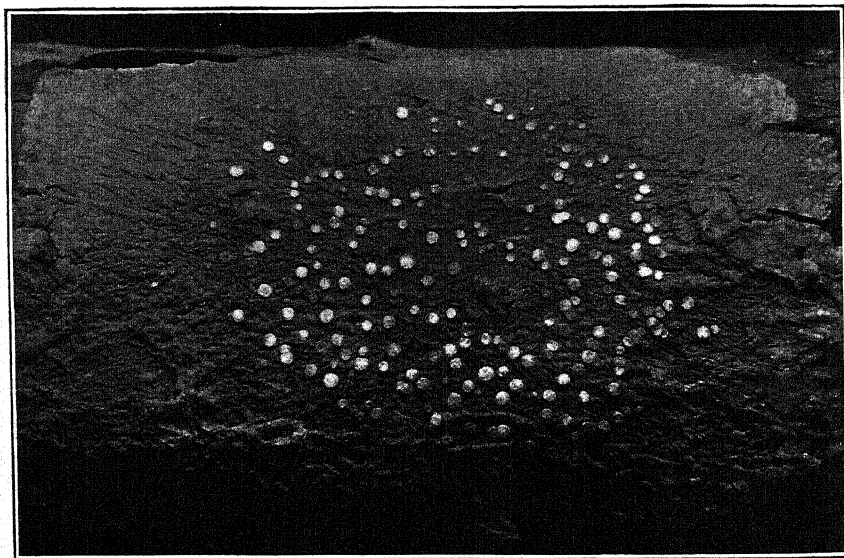
Thallus running over mosses, granulose or verrucose, whitish; apothecia middle-sized, brown, the exciple entire or flexuous.

The plant placed here was collected in the Misquah Hills. Among moss on a cedar tree.





A. *LECANORA HAGENI* ACH.



B. *PERTUSARIA VELATA* (TURN.) NYL.

The plant is definitely reported from various points in British America. Thus apparently arctic or alpine. Known also from northern Europe and Asia.

7d. *Lecanora subfusca argentata* Ach. Lich. Univ. 393. 1810.

Parmelia subfusca argentata Ach. Meth. Lich. 169. 1803.

Thallus rather thin and smooth, whitish; apothecia smaller, scarcely ever exceeding 1.5 mm. in diameter, the exciple usually entire; spores rather small.

Generally distributed over the State. On trees. Probably the most common subspecies, though less easily noted than the next.

Though seldom recorded, no doubt generally distributed over North America. Known also in South America and Europe.

7e. *Lecanora subfusca coilocarpa* Ach. Lich. Univ. 393. 1810.

Thallus rather thin, but becoming more or less granulose and chinky, whitish; apothecia rather small, scarcely exceeding 1.25 mm. in diameter, flat or slightly concave, the disk black and the exciple usually entire. The whole structure may become coarser, with larger apothecia, the black disk being still present.

The most noticeable subspecies and generally distributed over the State. On trees and more rarely on rocks.

No doubt occurring in all portions of North America. Known also in South America and Europe.

7f. *Lecanora subfusca distans* (Ach.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 160. 1861.

Parmelia distans Ach. Meth. Lich. 168. 1803.

Thallus thin and whitish; apothecia small or minute, 0.5 to 1 mm. in diameter, the disk pale brown or flesh-colored, the exciple subentire or obscurely crenulate; spores the smallest of the species.

The plant was collected at Mankato. On sandstone, but doubtless occurring elsewhere in the State on trees. Easily passed over for a *Lecidea* or *Rinodina*.

Like the other subspecies, not often noted, yet doubtless widely distributed in North America. Known in all of the grand divisions.

7g. *Lecanora subfusca sorediifera* Th. Fr. Lich. Scand. 1: 239. 1859.

Thallus commonly verrucose, breaking more or less into conspicuous whitish soredia; apothecia rather small, absent or few, the exciple entire or obscurely crenulate; said to disappear sometimes.

Generally distributed over the northern portion of the State. On trees. Also occurs farther south in the State and in Iowa, but has thus far been met only in the sterile condition.

Apparently not noted elsewhere in North America. Known in Europe.

Lecanora variolascens is the synonym of the preliminary reports.

8. *Lecanora hageni* Ach. Lich. Univ. 367. 1810.

PLATE 34, A.

Lichen hageni Ach. Lich. Suec. 57. 1798.

Thallus crustose, smooth and thin, but passing into leprose-verrucose or verrucose conditions, limited in size or widely spread over the substratum, the scales or verrucae sometimes more or less scattered or the whole thallus disappearing, without definite cortex, dirty-greenish, ashy or whitish; apothecia small or minute, 0.4 to 1 mm. in diameter, commonly flat, thin and adnate, the disk from pale brown to blackish and sometimes more or less gray-pruinose, the exciple usually whitish and almost always more or less crenate, rarely flexuous or disappearing; hypothecium pale or slightly brownish; hymenium pale throughout or brownish above; paraphyses simple or rarely branched, sometimes slightly enlarged and darker toward the apex; asci clavate; spores oblong-ellipsoid, 7 to 14 μ long and 4 to 6 μ wide.

A variable lichen. A rather large-fruited form, collected on limestone at St. Cloud by Mr. Arthur Morgan, has been referred by Dr. A. Zahlbruckner to *Lecanora dispersa*. This plant, however, seems quite as much at home with the present species and in some respects appears quite like certain forms of *Lecanora subfusca*.

The species is generally distributed over the State. On rocks and old wood.

Distributed throughout North America. Known also in Europe and Asia.

EXPLANATION OF PLATE 34.—A, Plant of *Lecanora hageni* on rocks, showing the apothecia. B, Plant of *Pertusaria velata* on branch of tree, showing the crustose thallus and the apothecia. A enlarged $1\frac{1}{2}$ diameters; B, $1\frac{1}{2}$ diameters.

9. *Lecanora dispersa* (Pers.) Floerke, Deutsch. Lich. 3: 4. 1815.

Lichen dispersus Pers. Ann. Bot. Usteri 7: 27. 1794.

Thallus of scattered and small and inconspicuous dirty greenish or whitish scales or granules, or entirely disappearing, or in a form on limestone, continuous beneath the clustered apothecia, these covering areas from 5 to 20 mm. in diameter; apothecia also scattered or more rarely clustered, commonly minute, but sometimes larger, 0.4 to 1.5 mm. in diameter, adnate, when crowded more or less angular, the disk flat, yellowish-brown to olivaceous, the exciple much as in the last, sometimes more or less pruinose and more inclined to entire conditions; hypothecium pale; hymenium pale below and commonly somewhat darkened above; paraphyses simple or rarely branched, quite inclined to cohere, sometimes slightly enlarged and darker toward the apex; asci clavate; spores ellipsoid, 8 to 12 μ long and 3.5 to 5.5 μ wide, thus somewhat smaller than in the European plants examined.

Closely related to the last above, but generally regarded as a distinct species.

Collected at Warroad, at Le Clair, and at Rainy Lake City. On old wood. A plant from the limestone at St. Cloud has been referred here by Doctor Zahlbruckner. See note under *Lecanora hageni*.

Elsewhere in North America in Labrador or Newfoundland. Known also in Europe, Asia, Africa, and New Zealand.

10. *Lecanora sambuci* (Pers.) Nyl. Not. Sällsk. Faun. Flór. Fenn. 5: 168. 1861.

Lichen sambuci Pers. Ann. Bot. Usteri 7: 26. 1794.

Thallus crustose and rather thin, smooth or passing into granulose or subleprose conditions, spread over the substratum in rather large and usually irregular patches, 35 to 90 mm. across, whitish or ashy in color, in ours the crust continuous and usually conspicuous by its color, but said sometimes to disappear almost entirely; apothecia small or minute, 0.5 to 1 mm. in diameter, adnate, the disk flat or convex, flesh-colored to light brown, the exciple white or whitish, in ours entire or subentire and rarely disappearing, said to be crenulate in European specimens; hypothecium pale; hymenium pale throughout or somewhat brownish above; paraphyses simple or rarely branched, sometimes slightly enlarged and darker toward the apex; asci clavate or ventricose-clavate; spores ellipsoid, 8 to 12 μ long and 5 to 7 μ wide, varying from 8 to 32 in each ascus, in ours usually 12 to 16.

Collected in the northeastern portion of the State at Grand Portage, in the Misquah Hills, and at Tofte. On trees, especially balsams.

Elsewhere in North America in Massachusetts and Illinois. Known also in Europe.

11. *Lecanora varia* (Hoffm.) Ach. Lich. Univ. 377. 1810.

Patellaria varia Hoffm. Descr. Pl. Crypt. 1: 102. pl. 23. f. 4. 1790.

Thallus crustose and thin, thick, or even disappearing, smoothish or verrucose-urceolate, suborbicular, 15 to 60 mm. in diameter, or irregular and widely spread over the substratum, pale greenish, yellowish, or whitish; apothecia small or minute, 0.4 to 1 mm. in diameter, adnate or more or less immersed, the disk flat or convex and flesh-colored or passing into yellowish or buff, the exciple entire or crenulate, sometimes disappearing; hypothecium pale; hymenium of the same color below and

frequently brownish above; paraphyses simple or rarely branched toward the apex, there sometimes enlarged and darker; asci clavate; spores ellipsoid or oblong-ellipsoid, 10 to 14 μ long and 4 to 7 μ wide.

Generally distributed over the State. On trees and old wood and rarely on rocks.

The species is distributed throughout North America. Known also in all of the grand divisions.

11a. *Lecanora varia symmicta* Ach. Lich. Univ. 379. 1810.

Thallus thin, smooth or becoming subleprose, most commonly yellowish; apothecia becoming convex and the exciple entire or disappearing, the disk of the usual colors or blackening.

Generally distributed over the State. On old wood, especially old boards.

The plant has a general North American distribution. Known also in Europe and Asia.

11b. *Lecanora varia saepincola* (Ach.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 164. 1861.

Lecidea saepincola Ach. Syn. Lich. 35. 1814.

Thallus thick, more or less granulate-roughened, of same color as the last; apothecia of the usual size, the disk convex and reddish-olivaceous or black, slightly pruinose, the exciple commonly absent and the apothecia biatoroid. Apothecia frequently lighter-colored in ours.

Recorded only from the northern portion of the State, but no doubt also occurring farther south. On old wood.

Not so frequently reported as the last, but still widely distributed in North America. Known also in Europe.

12. *Lecanora polytropa* (Hoffm.) Schaer. Enum. Lich. Eur. 81. 1850.

Verrucaria polytropa Hoffm. Deutsch. Fl. 2: 196. 1795.

Thallus crustose or subsquamulose of small squamules, thicker than in the last, somewhat roughened and chinky or becoming subareolate, or rarely even heaped-granulate, the crust continuous or scattered over larger or smaller areas, or sometimes disappearing, pale sea-green varying toward yellowish; apothecia small or scarcely middle-sized, 0.5 to 1.3 mm. in diameter, adnate, the disk flat with an entire, flexuous, or subcrenulate exciple, or even becoming convex and the exciple disappearing, somewhat darker-colored than the thallus or scarcely differing; hypothecium and hymenium pale; asci clavate; paraphyses simple or rarely branched toward the very slightly enlarged and colored apex; spores ellipsoid, 10 to 13 μ long and 5 to 6 μ wide.

Easily confused with forms of *Lecanora muralis*.

Reported from several localities in the northwestern portion of the State, and no doubt to be found farther east also. On rocks.

Elsewhere in North America in the mountains of New England and California and northward to arctic America. Known also in South America, Europe, and Asia.

Lecanora varia polytropa is the synonym of the preliminary reports.

12a. *Lecanora polytropa melaena* Hedl. Bih. Svensk. Vet. Akad. Handl. 18^m. 3: 38. 1892.

Thallus composed of contiguous or scattered, entire or subcrenate areoles or squamules; apothecia immersed or more or less superficial, scarcely reaching 1 mm. in diameter; the disk flat or becoming convex or even subglobular.

A single collection was made in 1903 on Mount Josephine at Grand Portage. On rocks.

Not previously reported from North America. Found in the Scandinavian Peninsula in Europe.

13. *Lecanora erysibe* (Ach.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 167. 1861.

Lichen erysibe Ach. Lich. Suec. 50. 1798.

Thallus crustose and somewhat thin, composed of olivaceous granules, which vary in color toward ashy or greenish, and run together to form a leprose or subareolate crust, suborbicular and 10 to 25 mm. in diameter, or more frequently irregular and more widely spread over the substratum, the areoles or granules rarely somewhat scattered; apothecia small or minute, 0.5 to 1 mm. in diameter, adnate, the disk flat or more or less convex, brown (in ours more usually black or blackish-brown), the exciple entire or crenulate, sometimes disappearing; hypothecium pale; hymenium pale beneath and brownish above; paraphyses simple or rarely branched, often slightly enlarged and darker toward the apex; asci clavate to cylindrico-clavate; spores ellipsoid, sometimes obscurely 2-celled, 10 to 14 μ long and 4 to 6 μ wide.

Collected at Minneapolis, at Mankato, and at Granite Falls. On rocks.

Elsewhere in North America in Illinois and Iowa. Known also in Europe.

14. *Lecanora pallescens* (L.) Schaer. Enum. Lich. Eur. 78. 1850.

Lichen pallescens L. Sp. Pl. 1142. 1753.

Thallus crustose, of moderate thickness and smoothish and chinky or becoming plicate, rarely rugose or even tuberculate-areolate, whitish or darker-ashy, suborbicular and of medium size, 15 to 60 mm. in diameter, or irregular and more widely spread over the substratum; apothecia middle-sized or larger, 1 to 2.5 mm. in diameter, the disk flat or more or less concave, flesh-colored varying toward whitish or yellowish, usually more or less white-pruinose, the exciple erect and entire or subentire; hypothecium pale; hymenium of the same color; paraphyses simple or rarely branched, frequently somewhat enlarged and colored toward the apex; asci clavate, cylindrico-clavate, or variously irregular, the whole wall thickened; spores ellipsoid and ovoid-ellipsoid, said to be 50 to 90 μ long and 20 to 40 μ wide, but ours sometimes only 35 μ long.

The above and the next following are scarcely well differentiated in our lichen flora and the determinations are difficult and uncertain.

Found throughout the northern portion of the State. On trees and most common on cedars in swamps.

Distributed throughout North America. Known in all of the grand divisions except Australia.

15. *Lecanora tartarea* (L.) Ach. Lich. Univ. 371. pl. 7. f. 3. 1810.

Lichen tartareus L. Sp. Pl. 1141. 1753.

Thallus crustose, thicker, and more roughened than in the last (tartareous), composed of coarser granules, which may be conglomerate and form a thick crust or more scattered when the crust is very uneven, of the same color as the last, and similarly disposed upon the substratum; apothecia middle-sized or large, 1 to 3 or in material from other States even 5 mm. in diameter, sessile or adnate, the disk yellowish and passing into brownish or brick-colored, scarcely pruinose, flat or concave, the exciple rather thick and entire or wavy; hypothecium pale; hymenium pale below and frequently more or less brownish above; paraphyses very slender, simple or rarely branched, sometimes slightly enlarged and colored toward the apex; asci clavate or more or less irregular, the walls thickened; spores ellipsoid to ovoid-ellipsoid, 30 to 65 μ long and 20 to 35 μ wide.

Collected at Ely. Some material referred to the last from the trees seems quite as much like the present, following Tuckerman's idea as to spore measurements. The collection from Ely, which undoubtedly belongs here, was made on rocks.

Generally distributed over North America, but hardly so common as the last. Known also in all of the grand divisions except Australia.

16. *Lecanora melanaspis* Ach. Lich. Univ. 427. 1810.

Parmelia melanaspis Ach. Meth. Lich. 196. 1803.

Thallus thick, crustose, and becoming verrucose-rugose or subareolate or, especially toward the margin, subfoliose, and showing linear, branched, and more or less imbricated lobes, ashy to whitish or brownish, covering considerable areas and showing a suborbicular tendency (plants at hand being 25 to 50 mm. in diameter), well developed and showing a cortical layer; apothecia small to middle-sized, 1 to 2 mm. in diameter, adnate or closely sessile, the disk flat or more or less convex, dark brown to blackish and rarely pruinose, the exciple commonly entire, but rarely becoming somewhat irregular or tending to disappear; hypothecium pale; hymenium pale beneath, usually brownish above; paraphyses simple or rarely branched, frequently enlarged, and somewhat darkened toward the apex; asci clavate; spores short-ellipsoid, 8 to 14 μ long and 5 to 9 μ wide.

The plant seems near *Lecanora rubina* in respect to thallus structure and should perhaps be placed nearer that species.

Collected at Granite Falls. On rocks.

Elsewhere in North America in Greenland, Nebraska, Kansas, South Dakota, and California. Known also in Europe.

Lecanora sp. of the fifth report of the preliminary survey.

17. *Lecanora mutabilis* (Ach.) Nyl. Mém. Soc. Sci. Nat. Cherb. 2: 324. 1854.

Urceolaria mutabilis Ach. Lich. Univ. 335. 1810.

Thallus crustose and of moderate thickness, verrucose, chinky or subareolate, dark-ashy or varying toward yellowish, usually suborbicular and middle-sized, 25 to 80 mm. in diameter; apothecia small or minute, 0.5 to 1 mm. in diameter, immersed or becoming superficial, the disk concave and urceolate, commonly black, surrounded by a proper exciple and this in turn by an inflexed thalloid one; hypothecium pale; hymenium pale throughout or darkened above; asci cylindrico-clavate to short-clavate; paraphyses slender and variously curved, simple or branched; spores roundish-ellipsoid, 30 to 52 μ long and 16 to 35 μ wide.

The plant is generally distributed over the northern portion of the State, but has been confused with *Pertusaria leioplaca*. On trees.

Elsewhere in North America in Massachusetts and New York. Known also in Europe and Africa.

Lecanora verrucosa mutabilis of the preliminary reports.

18. *Lecanora cinerea* (L.) Sommerf. Suppl. Fl. Lapp. 99. 1826.

Lichen cinereus L. Mant. Pl. 1: 132. 1767.

Thallus crustose, of moderate thickness and more or less roughened; commonly plainly areolate but sometimes smoother and chinky, or rarely verrucose rather than areolate, the areoles or verrucae commonly about 1 mm. in diameter, ashy (cinereous) varying toward whitish or brownish, sometimes orbicular, 30 to 85 mm. in diameter, or becoming irregular and more widely spread over the substratum, in the orbicular conditions the margin sometimes delicately zonate; apothecia small to almost middle-sized, or sometimes minute, 0.5 to 1 mm. in diameter (or 1.5 according to Nylander), immersed, the disk commonly flat and black, the exciple entire and sometimes blackening; hypothecium pale; hymenium pale below and frequently brownish or olivaceous above; paraphyses simple or rather rarely branched, the apices sometimes slightly enlarged and colored; asci clavate; spores ovoid or ellipsoid, 14 to 26 μ long and 7 to 16 μ wide.

The plant is very variable, and it might perhaps conduce to clearness to follow the European lichenists in recognizing even a larger number of subspecies.

Generally distributed over the State. On rocks other than calcareous.

Known throughout North America. Found in all of the grand divisions except Australia.

18a. *Lecanora cinerea laevata* (Fr.) Tuck. Syn. N. A. Lich. 1: 198. 1882.

Parmelia cinerea laevata Fr. Lich. Eur. 145. 1831.

Thallus thinner and smooth but becoming somewhat chinky, never areolate; surface usually more or less shining; apothecia always immersed, minute and often irregular.

Throughout the northern portion of the State and as far south as Taylors Falls. On rocks other than calcareous.

Reported from North American stations as remote as Labrador, Alabama, and California, and no doubt generally distributed, though rare. Known also in Europe and Asia.

18b. *Lecanora cinerea gibbosa* (Ach.) Tuck. Syn. N. A. Lich. 1: 198. 1882.

Lichen gibbosus Ach. Lich. Suec. 30. 1798.

Thallus thick and conspicuously roughened-verrucose or areolate, on the whole darker than the last; apothecia becoming superficial and larger; spores also rather larger.

Generally distributed in the State. On the same substrata and more common than the last.

No doubt as widely distributed in North America as the species, though apparently not yet noted from the Southern States. Found also in Europe and Asia.

18c. *Lecanora cinerea microspora* Fink.

Thallus roughened and verrucose-areolate, thinner and finer than in the last, blackish-olivaceous; apothecia and spores small, the latter in ours 11 to 16 μ long and 6 to 10 μ wide.

Collected in the Leaf Hills. On granitic boulders.

Not known elsewhere in North America. Found in Europe.

Lecanora gibbosa microspora of the preliminary reports, this unpublished name having been communicated by Dr. A. Zahlbruckner.

19. *Lecanora calcarea* (L.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 154. 1861.

Lichen calcareus L. Sp. Pl. 1140. 1753.

Thallus crustose, scarcely so much roughened as usual forms of the last, chinky, verrucose, or areolate, sea-green, ashy or rarely white and mealy, continuous, irregular, and spread over considerable areas, or ours more commonly inconspicuous, scattered or obscured by the numerous apothecia; apothecia of same size as those of the last, commonly immersed but in ours becoming adnate in the usual form with poorly developed thallus, the disk urceolate or flat, light brown to blackish and commonly white-pruinose, the exciple entire or rugose-plicate and surrounding a thin proper exciple; hypothecium pale; hymenium pale below and more or less colored above; paraphyses simple or branched, commonly enlarged and brownish toward the apex; asci clavate or ventricose-clavate; spores 2 to 8 in each ascus, ovoid to ellipsoid, in ours 10 to 14 μ long and 4 to 6 μ wide and 8 in each ascus (said to be 16 to 30 μ long and 12 to 20 μ wide).

The plants referred here for Minnesota and Iowa may all be regarded as doubtful, the spores being small and the thallus poorly developed. Some of the forms from the calcareous rocks are the same as were referred here by Tuckerman. Others are too near the last above, and the one reported from Mankato is much like some forms referred to *Lecanora dispersa*.

Reported from various portions of the State, but the more probable forms are from regions where calcareous rocks occur. On rocks.

Throughout the northern United States and northward into British America. Known also in Europe and Africa.

19a. *Lecanora calcarea contorta* (Hoffm.) Tuck. Syn. N. A. Lich. 1: 199. 1882.

Verrucaria contorta Hoffm. Descr. Pl. Crypt. 1: 97. pl. 22. f. 1-4. 1790.

Thallus better developed, areolate and the areoles frequently more or less scattered, commonly pale greenish lead-colored; apothecia scarcely becoming adnate and the disk sometimes punctiform; often four spores in each ascus, and the spores of the larger size mentioned above.

The subspecies is well marked.

Generally distributed over the State. On various rocks, but more common on calcareous.

Elsewhere in North America in Greenland, and various portions of the United States from Alabama northward to Illinois and westward to California. Known also in all of the grand divisions except Australia.

20. *Lecanora lacustris* (With.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 155. 1861.

Lichen lacustris With. Arr. Brit. Pl. ed. 3. 21. 1796.

Thallus crustose and usually thin, smooth and only slightly chinky, but becoming thicker and plainly areolate, ashy or more commonly varying toward pale brick-colored or pale olivaceous, occurring in irregular patches, in the specimens at hand 15 to 80 mm. across; apothecia small or rather minute, 0.2 to 0.5 mm. in diameter, immersed and usually urceolate, in areolate thalli usually several in each areole, the disk reddish or brownish; hypothecium pale or slightly cloudy; hymenium pale below and commonly somewhat colored above; paraphyses simple or rarely branched, the apices sometimes enlarged and slightly colored; asci clavate; spores oblong-ellipsoid, 11 to 17 μ long and 4 to 6 μ wide.

Collected at Tower. On rocks along the shore of Vermillion Lake, in places often inundated.

Elsewhere in North America, in Alaska, Greenland, New England, and Alabama. Known in Europe and Asia.

21. *Lecanora subepulotica* (Nyl.) Fink.

Lecidea subepulotica Nyl. Mém. Soc. Sci. Nat. Cherb. 4: 337. 1857.

Thallus crustose and thickened, verrucose or areolate, whitish-ashy, in ours forming small thickened areas from 2 to 6 mm. in diameter, these frequently running together to form larger patches; apothecia small, 0.2 to 0.6 mm. in diameter, adnate, the disk flat, convex or more or less irregular, flesh-colored to reddish and darkening, the exciple soon disappearing, and the whole structure becoming biatoroid, the exciple when present and the whole apothecium as well tending to be irregular in form; hypothecium pale-brownish to brown; hymenium pale reddish brown; paraphyses commonly simple, very slender, sometimes slightly enlarged and brownish toward the apex; asci cylindrico-clavate; spores ovoid-ellipsoid, 10 to 16 μ long and 6 to 9 μ wide, tending to uniseriate arrangement in the asci.

Frequently regarded a subspecies of the last, but ours is quite distinct.

Collected along the northern boundary near Emo. On rocks along Rainy River.

Elsewhere in North America in Canada, Vermont, Massachusetts, and California. Known also in Europe.

HAEMATOMMA Mass. Ric. Lich. 32. f. 53-54. 1852.

The thallus is crustose and usually thin. In some of the species there is a more or less developed upper cellular cortex, while in others no other cortical structure is present than a thin layer of gelatinized and often scarcely distinct hyphæ. The algal and medullary layers are not often distinctly differentiated, while the lower cortical layer seems to be uniformly absent. Hyphal rhizoids form the attaching organs. The algal symbionts are rather large, but do not seem to differ otherwise from the

ordinary *Cystococcus*. In most of the species soredia occur scattered over the upper surface of the thallus. Shades of sea-green and yellow are the prevailing colors of the thalli.

The apothecia are of medium size or larger and are either sessile or adnate. The exciple shows much the same structure as the upper cortex and is thus scarcely so well developed as that of the *Lecanoras*. The algæ of the exciple are not numerous, and the whole structure appears to be somewhat biatoroid. Indeed, the exciple may disappear entirely, leaving the apothecium strictly biatoroid. The hypothecium is pale. The paraphyses are slender, and commonly simple, though branched forms may be looked for in all of the species. The spores are long and acicular, hyaline, variously curved, and 4 to several-celled.

The relations of the genus are not difficult to trace. As to the structure of the thallus and the apothecia the resemblance to a majority of the *Lecanoras* is apparent enough. When we turn to the spores, we note a similarity to those of the *Bacidias*. The thallus also is only a little higher in development than that of the *Bacidias*, while the poorly developed thalloid exciple points to a more or less close relationship with the same genus. On the whole, it may well be doubted whether the present genus is more closely related to *Lecanora* than to *Bacidia*.

Only a few species of the genus are known in North America, and of these only one has been noted in Minnesota.

Type species *Haematomma vulgare* Mass. loc. cit.

1. *Haematomma elatinum* (Ach.) Koerb. Syst. Lich. 153. 1855.

Lecanora elatina Ach. Lich. Univ. 387. 1810.

Thallus crustose and thin, smooth and somewhat chinky or more commonly becoming densely granulate or powdery, ashy-white or faintly yellowish, closely adnate and attached by hyphal rhizoids, in the less powdery conditions an upper pseudo-cortex distinguishable as a thin structureless and gelatinized mass or faintly showing coherent hyphæ; apothecia small to middle-sized, 0.5 to 1.5 mm. in diameter, sessile, the disk commonly flat or finally convex, and from light brownish to dark reddish brown, frequently somewhat pruinose, the thalloid exciple irregular and evanescent, leaving the apothecium strictly biatoroid; hypothecium pale; hymenium of the same color or darker above; paraphyses simple or rarely branched toward the commonly thickened and somewhat colored apex; asci clavate or cylindrico-clavate; spores fusiform-acicular, curved, 4 to 6-celled, 38 to 58 μ long and 4 to 6 μ wide.

A single collection has been made, at Tofte. On trees.

Found in New England, New York, North Carolina, and northward throughout British America. Known also in Europe and Asia. Perhaps more widely distributed, but the synonymy is uncertain.

Lecanora elatina of the preliminary reports.

Family PERTUSARIACEAE.

In the *Pertusariaceae* we have a family which is extremely troublesome, though composed of a single genus. We have followed Zahlbruckner in recognizing the family, but have not seen our way to follow him in separating the large-spored *Lecanoras*, *L. tartarea* and *L. pallescens*, under the generic name *Ochrolechia*, and placing them in the present family. It is true, however, that certain members of the present family tend toward the open condition of apothecium and seem very closely related to these *Lecanoras*. We have recognized this close relationship in placing the *Pertusariaceae* next after the *Lecanoraceae*.

On the other hand, the apothecia more commonly open by an apical pore, and Schneider has seen fit to place the genus *Pertusaria* with the *Verrucariaceae* without recognizing the family *Pertusariaceae* at all. And his position is not without strong

claims when we consider the close structural relationship of the apothecia of a large number of *Pertusarias* with those of the *Trypetheliums*, not represented in our flora. In placing the present family next to the *Lecanoraceae*, it is only fair to admit this other perhaps equally close relationship.

The crustose thallus, the nature of the algal symbiont, the peculiar grouping of the apothecia in verrucæ of the thallus (the grouping quite *Trypethelium*-like), and the large size of the spores all receive attention in the description of the genus.

PERTUSARIA Lam. & DC. Fl. Fr. ed. 3. 2: 319. 1805.

The thallus is strictly crustose. In one or two species, however, a poorly developed upper cellular cortex can be made out. In others there is a thin upper pseudo-cortex of interwoven hyphæ, which are frequently gelatinized into a structureless layer. The algal and medullary layers are frequently well differentiated, but in none of our species is any suggestion of a lower cortex found. Hyphal rhizoids serve as attaching organs after the manner of crustose thalli in general. The thallus varies considerably in thickness, and in at least one of our species it is mainly hypophloeodal. Sea green and ashy are the common colors. The algal symbionts are *Cystococcus*, and the algal cells are quite uniform in the different species, apparently scarcely modified by their association with the fungal symbionts.

The apothecia are small or minute, commonly globose and immersed in the elevations or verrucæ of the thallus, often a half dozen or more in a single verruca. The apothecium commonly opens by a small pore, which is not always evident except in sections cut through it. However, in some of the species the apothecia or the verrucæ become open and disk-like, or rather the globular structure becomes depressed, for the thallus which always covers the structure either remains intact or breaks up into a sorediate mass. The paraphyses are commonly more or less branched and hyaline throughout. The hypothecium and hymenium are pale, or the latter sometimes brownish above. The asci are clavate, cylindrico-clavate, or variously irregular, with rather thick walls. The spores are hyaline or pale, very large and simple, though some authors admit 2-celled forms. There are from 1 to 8 spores in each ascus, and the spore walls are quite thick.

The relationships of the genus are by no means certain. The thallus structure and the spores look toward *Lecanora* and allied genera. The very presence of what may be regarded a perithecium would seem to indicate a close relation to *Pyrenula* and *Trypethelium*. However, the so-called perithecium is here quite a different structure, and the thallus is much better developed and commonly epiphloeodal. Tuckerman gives one view of relationships clearly in his genera.^a Seven species and sub-species occur in the State. On trees and rarely on rocks.

Type species *Pertusaria communis* DC. loc. cit.

KEY TO THE SPECIES.

Thallus usually lighter-colored or zonate toward the circumference.

Thallus usually becoming rough.

Spores 130 to 250 μ long, one in each ascus..... 1. *P. velata*.

Spores 75 to 150 μ long, one or two in each ascus..... 2. *P. multipuncta*.

Thallus smooth and thin; spores as in the last above..... 2a. *P. multipuncta ophthalmiza*.

Thallus scarcely lighter-colored or zonate toward the circumference.

Apothecia 2 to several in each verruca; spores 100 to 180 μ long, 1 or 2 in each ascus..... 3. *P. communis*.

Apothecia 1 to 5 in each verruca.

Spores 4 to 8 in each ascus..... 6. *P. leioplaca*.

Spores 1 or 2 in each ascus.

Thallus sea-green to ashy, yellowish or brownish;

apothecia-containing verrucæ somewhat raised... 4. *P. pustulata*.

Thallus whitish; apothecia-containing verrucæ

flattish..... 5. *P. finkii*.

1. *Pertusaria velata* (Turn.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 179. 1861.

Parmelia velata Turn. Trans. Linn. Soc. Lond. 9: 143. *pl. 12. f. 1.* 1808.

PLATE 34, B.

Thallus rather thin and smooth or becoming thicker and plicate-rugose, chinky or somewhat irregularly roughened or verrucose, sea-green to milky-white, suborbicular, 3.5 to 10 cm. in longest dimension, the circumference commonly lighter-colored and frequently zonate, the upper pseudocortex of interwoven hyphæ and becoming a structureless mass; apothecia immersed 2 or 3 in a small to almost middle-sized verruca, this 0.4 to 1.2 mm. in diameter, depressed and disk-shaped, the disk concave and usually lighter than the thallus, and sometimes densely white-sorediate; hypothecium commonly pale; hymenium pale below and commonly brownish above; paraphyses quite commonly branched, not often enlarged or darker toward the apex; asci cylindrical or cylindrico-clavate; spores oblong-ellipsoid, 150 to 250 μ long and 40 to 80 μ wide, one in each ascus, or, according to Tuckerman, rarely two.

Found throughout the State. On trees and rarely on rocks.

Throughout eastern North America and westward to the Rocky mountains. Also in Alaska. Known in all of the grand divisions.

EXPLANATION of Plate 34.—See page 180.

2. *Pertusaria multipuncta* (Turn.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 179. 1861.

Variolaria multipuncta Turn. Trans. Linn. Soc. Lond. 9: 137. *pl. 10. f. 1.* 1808.

Thallus much as in the last, but on the whole inclined to be thinner and smoother, sea-green to pale ashy, more inclined to irregularity in form and either not lighter and zonate toward the circumference or indistinctly so, cortex as in the last or even less developed; apothecia-containing verrucæ also much as in the last, but not so uniformly depressed and disk-like, frequently becoming irregular and blackened, or passing into powdery-sorediate heaps, numbering 2 to 4 in each verruca; hypothecium, hymenium, and paraphyses as in the last; asci more inclined to be clavate or ventricose; spores distinctly smaller, 75 to 150 μ long and 25 to 65 μ wide, one in each ascus, or rarely two.

Throughout the northern portion of the State. On trees.

Distributed throughout North America. Found also in all the grand divisions except Africa.

2a. *Pertusaria multipuncta ophthalmiza* Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 180. 1861.

Thallus thin and smooth; apothecia-bearing verrucæ uniformly disk-like and blackening above, usually scattered and each containing a single apothecium.

Distribution in the State as that of the species. On trees and old wood.

Elsewhere in North America in Newfoundland or Labrador. Known also in Europe.

Pertusaria ophthalmiza and *P. multipuncta laevigata* of the preliminary reports.

3. *Pertusaria communis* Lam. & DC. Fl. Fr. ed. 3. 2: 320. 1805.

FIGURE 15.

Thallus thin and smoothish or soon becoming rougher and chinky and finally strongly rugose-verrucose and subareolate, sea-green or lighter-colored and rarely somewhat zonate at the circumference, commonly irregular and often widely spread over the substratum, the layers distinct, but the upper cortex commonly a structureless gelatinized mass; apothecia-containing verrucæ 0.5 to 2 mm. in diameter, de-

pressed-subglobose (not disk-shaped) and variously irregular, apothecia 2 to several in each verruca, and the verrucæ closed except at the sunken, commonly black but usually inconspicuous pores of the apothecia; hypothecium pale; hymenium pale below and sometimes more or less brownish above; paraphyses slender and usually

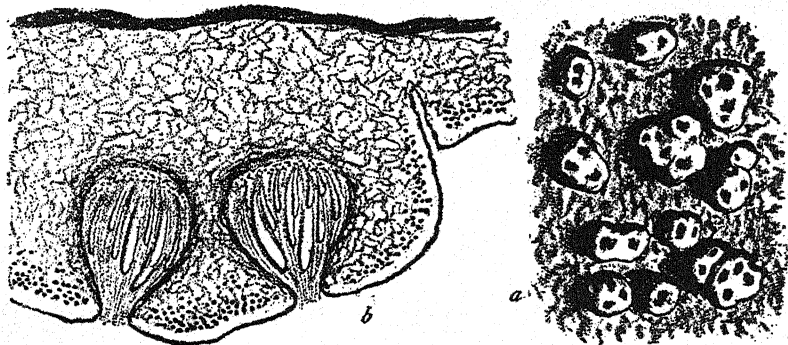


FIG. 15.—*Pertusaria communis*. *a*, Thallus with the apothecia-containing verrucæ and the ostioles; *b*, a section of a verruca, showing two of the immersed apothecia. *a*, Enlarged 3 diameters; *b*, 30 diameters. From Reinke.

more or less branched; asci cylindrical or cylindrico-clavate; spores 100 to 180 μ long and 40 to 70 μ wide, 1, 2 (or rarely 4 ?) in each ascus.

Generally distributed throughout the State. On trees and rarely on dead wood or rocks.

Found throughout North America. Known in some form in all of the grand divisions.

4. *Pertusaria pustulata* (Ach.) Nyl. Act. Soc. Linn. Bord. 21: 441. 1856.

Porina pustulata Ach. Lich. Univ. 309. 1810.

Thallus thinner and smoother than that of the last, but becoming chinky or even somewhat verrucose, sea-green varying toward ashy, yellowish or brownish, often sub-orbicular, 2.5 to 4 cm. across, or irregular and covering smaller areas of the substratum than that of the last, upper cortex as in the last and the thallus inclined to be partly hypophloeodal, or apparently more so than our other species; apothecia-containing verrucæ small, 0.4 to 1 mm. in diameter, only slightly raised; difform or becoming irregularly-hemispherical; apothecia 1 to 4 or 5 in each verruca, the black pores sometimes becoming conspicuous and disk-like; hypothecium pale; hymenium pale below and commonly brownish above; paraphyses slender and commonly branched, somewhat enlarged toward the apex; asci as in the last; spores oblong-ellipsoid, 50 to 135 μ long and 25 to 56 μ wide, 2 in each ascus.

Well distributed over the State. On trees.

Generally distributed over North America, but apparently not common toward the Pacific Coast. Known in all of the grand divisions.

5. *Pertusaria finkii* Zahlbr. in Fink, Minn. Bot. Stud. 2: 696. 1901.

Thallus thin and smooth or becoming chinky and somewhat verrucose, whitish in color, commonly occurring in small and somewhat irregular patches, scarcely more than 1.5 to 4 cm. across, without definite upper cortex; apothecia-containing verrucæ small to middle-sized, 0.5 to 2 mm. in diameter, flattened and rather inconspicuous; apothecia 1 to about 5 in each verruca, the pores brown or blackish, or the apothecium becoming open and disk-like and of the same color; hypothecium pale; hymenium pale below and brownish above; paraphyses slender and somewhat coherent, simple or branched, rarely enlarged or darker toward the apex; asci clavate or cylindrico-clavate; spores oblong-ellipsoid, sometimes constricted along the sides, 70 to 140 μ long, and 28 to 53 μ wide, 2, or rarely 1, in each ascus.

Found in several localities in the northern portion of the State. On hard wood trees, especially oaks and cottonwood, and to be looked for wherever these trees occur in northern Minnesota. Besides the localities noted in the sixth preliminary report, the plant was seen in 1902 at several points on the north shore of Lake Superior from Grand Marais to Duluth.

A North American lichen not known elsewhere.

6. *Pertusaria leioplaca* (Ach.) Schaer. Lich. Helv. Spic. 2: 66. 1823.

Porina leioplaca Ach. Lich. Univ. 309. pl. 7. f. 2. 1810.

Thallus thin and smooth or becoming somewhat chinky and verrucose, sea-green to pale yellowish, disposed upon the substratum much as in the last, but the patches on the whole smaller, also inclined to hypophloeodal conditions, some of ours showing a poorly developed upper cellular cortex (this no doubt sometimes existing in specimens of other species not thus credited, the plants varying somewhat in this respect even within a species); apothecia-containing verrucae small to middle-sized 0.6 to 2 mm. in diameter, hemispherical and somewhat irregular, scattered or crowded; apothecia one or few in each verruca, the pore rarely depressed and sometimes becoming black and conspicuous, or the whole verruca rarely becoming depressed and disk-like; hypothecium pale; hymenium pale beneath and commonly brownish above; paraphyses commonly branched and rarely somewhat enlarged toward the apex; asci cylindric-clavate; spores oblong-ellipsoid, 4 to 8 in each ascus and varying in size according to number, hence 40 to 180 μ long and 20 to 50 μ wide.

Not often collected, but no doubt generally distributed over the State. On trees.

Found throughout North America. Known in all of the grand divisions.

FAMILY PARMELIACEAE.

This family is represented in our flora by 6 genera, of which *Parmelia* is the largest, having more than 20 forms in the State. However, the whole family with its 6 genera has not as many species in our flora as the *Cladoniaceae* with their single genus. The family is most closely related to the *Lecanoraceae* below and to the *Physciaceae* and the *Teloschistaceae* above. The relationship with the *Lecanoraceae* was stated in the discussion of that family. Of the two families next preceding this it is not so easy to decide which is more closely related to it. If we consider superficial resemblance in color and form of thallus, doubtless the genus *Physcia* of the *Physciaceae* would stand nearest, but the spore characters should doubtless have greater weight. As regards the latter, the 2-celled spores of *Ramalina* look somewhat toward the similar but brown spores of *Physcia*, while colored spores are also found in the present family in *Alectoria*. Turning to the *Teloschistaceae*, however, every condition from the typical polar 2-celled spore to the simple spore is found in both of the two genera of the family, the nonpolar 2-celled spores being quite like those of *Ramalina*, and the much rarer simple ones not very different from those of the *Parmelias*. Thus we may bridge over an apparent difficulty in the polar spores, so that the *Teloschistaceae* appear after all closer to the *Parmeliaceae* than do the *Physciaceae*, and no doubt the *Physciaceae* should stand highest among the *Discocarpineae*.

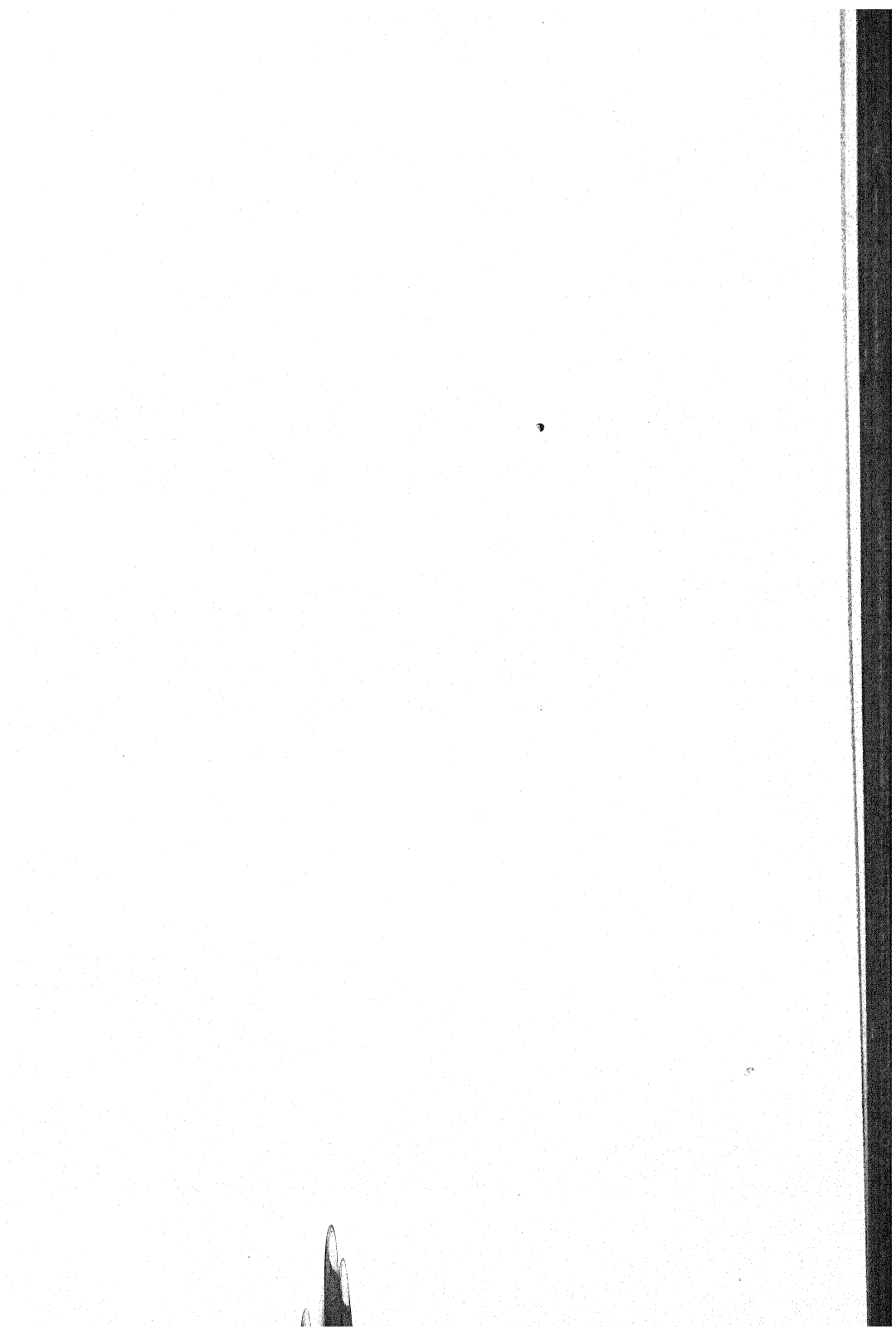
The thallus is either foliose with dorsiventral symmetry or fruticose with more or less well defined radial symmetry. A cellular cortex or a pseudocortex of hyphae is always present, the former in the foliose species and the latter usually in the more or less plainly fruticose ones. The algal symbiont is *Cystococcus*.

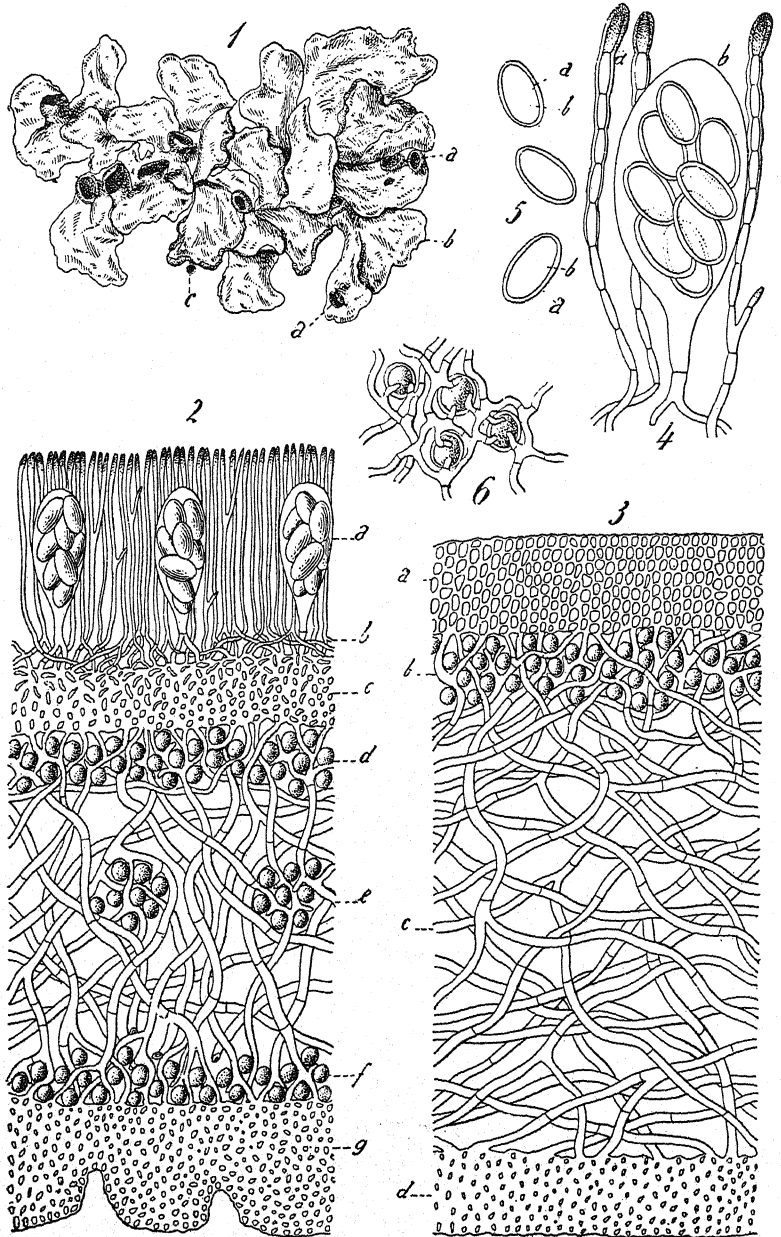
The apothecia vary in position from subpedicellate to immersed. The spores are simple or 2-celled and almost always colorless, those of some *Alectorias* being sometimes brownish.

PARMELIA Ach. Meth. Lich. xxxiii, 154. pl. 4. f. 8-6. 1803.

PLATE 35.

The thallus is foliose or rarely somewhat fruticose, the former in all of ours. In some species it is freely dichotomously lobed, while in others it is nearly entire, the margin





PARMELIA PERLATA (L.) ACH.

merely being more or less indented. Soredia and isidioid growths are quite common on the upper surface of the thallus, largely replacing apothecia as reproductive bodies. The upper and the lower cortical layers are cellular and well developed. The algal layer is in the usual position for dorsiventral thalli, viz, just below the upper cortical layer. The medullary tissue consists of the usual loosely interwoven hyphæ, and in some species the lower portion of this tissue is very loosely interwoven and contains large air spaces. Rhizoids are usually present on the lower surface of the thallus, and cilia frequently occur along the margins or on the upper surface. Spermatogones are conspicuous.

The apothecia are sessile or subpedicellate on the upper surface of the thallus, the thalloid margin is usually entire or more or less crenate, the disk is usually brown and often deeply concave, the hypothecium is pale or slightly colored and frequently shows two distinct layers, the hymenium is pale or yellowish or brownish tinged. The paraphyses are usually simple and slender, and the spores are simple, hyaline, and much alike in form and size in the different species. Apothecia are very rare in more than half of our species.

In appearance and structure of the thallus the genus seems near to *Physcia*, but when we take into consideration the spore characters, doubtless the relationship with *Cetraria* is closer. The relation between the present genus and the higher simple-spored *Lecanoras* with foliose thallus is also close. *Parmelia* seems to stand between *Lecanora* and *Cetraria*.

The genus is represented in Minnesota by no less than 22 forms and is the largest of our foliose genera.

Parmelias occur on trees, old wood, rocks, and rarely on the earth or over mosses.

Type species *Parmelia elacista* Ach. op. cit. 159. pl. 4. f. 4. But this is a *Lecanora* (*L. elacista*), and the generic name *Parmelia* would take precedence over *Lecanora*. See note under *Gyalecta*.

EXPLANATION OF PLATE 35.—Fig. 1, *a*, apothecia; *b*, the thallus. Fig. 2, a section of an apothecium and the thallus below; *a*, the hymenium; *b* and *c*, the hypothecium; *d*, the algal layer; *e*, the medullary layer; *f*, a lower algal layer; *g*, the lower cortex. Fig. 3, a section of the thallus; *a*, the upper cortex; *b*, the algal layer; *c*, the medullary layer; *d*, the lower cortex. Fig. 4, paraphyses and an ascus. Fig. 5, free simple spores. Fig. 6, algal cells, haustoria, and hyphæ. Fig. 1, natural size; figs. 2 and 3, enlarged 400 diameters; figs. 4, 5, and 6, enlarged 650 diameters. From Schneider.

KEY TO THE SPECIES.

Thallus never sea-green.

Thallus straw-colored.

Thallus large, with short, wide lobes; commonly on wood..... 13. *P. caperata*.

Thallus smaller, or with longer, narrower lobes; commonly on rocks.

Thallus medium-sized or larger, with long, narrow lobes..... 14. *P. conspersa*.

Thallus quite small, the center often falling away. 15. *P. centrifuga*.

Thallus olivaceous.

Apothecia absent in ours; a larger plant than the next, less closely adnate and isidioid or sorediate..... 12. *P. conspurcata*.

Apothecia present, at least usually.

Thallus lobes and the exciple densely covered with minute verrucæ..... 11a. *P. olivacea aspidota*.

Thallus lobes and exciple not verruca-bearing.

Thallus lobes much crowded and imbricated; on rocks..... 11b. *P. olivacea proliza*.

Thallus lobes not much crowded and imbricated; on wood..... 11. *P. olivacea*.

Thallus usually sea-green.

Thallus showing open spaces within (inflated).

Thallus punctured with small holes..... 9. *P. pertusa*.

Thallus not punctured with holes..... 8. *P. physodes*.

Thallus not inflated.

Thallus frequently more or less isidioid above.

Thallus densely beset above with granules or isidioid branchlets.

Thallus margin ciliate; dark and rhizoid-bearing below..... 4. *P. crinita*.

Thallus margin not ciliate; light-colored and rhizoid-bearing below..... 6a. *P. borrieri* *reducta*.

Thallus not densely beset above with granules or isidioid branchlets.

Thallus margin ciliate; dark and densely rhizoid-bearing below..... 1a. *P. perlata ciliata*.

Thallus margin not ciliate.

Thallus sorediate above, dark and rhizoid-bearing below..... 7a. *P. saxatilis sulcata*.

Thallus not sorediate above, dark and rhizoid-bearing below.

Thallus lobes long, not densely crowded and imbricated..... 7. *P. saxatilis*.

Thallus lobes short, densely crowded and imbricated..... 7b. *P. saxatilis paniformis*.

Thallus without isidioid branchlets above.

Thallus rather small, scarcely surpassing 90 mm. in diameter; below black and densely rhizoid-bearing..... 5. *P. tiliacea*.

Thallus larger, often reaching 15 cm. in diameter.

Thallus margin often ciliate.

Thallus dark below, where rhizoid-bearing; apothecia perforate.

Thallus quite rigid, rugose toward the center..... 2. *P. perforata*.

Thallus less often rugose, thinner margin; more often sorediate..... 3. *P. cetrata*.

Thallus light-colored below; apothecia perforate..... 2a. *P. perforata hydropotropa*.

Thallus margin not ciliate.

Thallus light-colored below, where rhizoid-bearing..... 6. *P. borrieri*.

Thallus dark below.

Thallus sorediate above, rather small; sparingly rhizoid-bearing below.... 10. *P. aleurites*.

Thallus not sorediate above, except sometimes at the margin, much larger; strongly rhizoid-bearing below..... 1. *P. perlata*.

1. *Parmelia perlata* (L.) Ach. Meth. 216. 1803.

PLATE 35.

Lichen perlatus L. Syst. Nat. ed. 12. 712. 1767.

Thallus prostrate, the margins usually slightly ascendant, commonly orbicular in outline, the somewhat imbricated lobes rather large, with rounded undulate margins, these without cilia but frequently clothed with white soredia; pale or darker sea-green above, below black with brown margins and clothed here and there with black rhizoids; good-sized or sometimes very large, commonly 7.5 to 20 cm. in diameter, in extreme examples reaching 45 cm.; apothecia of middle size, 4 to 8 mm. in diameter, with chestnut disk and entire margin; spores ellipsoid, 10 to 17 μ long and 6 to 10 μ wide.

Ours sterile and apothecia not seen. The above apothecial and spore characters are taken from Nylander.

Found only in the northern portion of the State and rather infrequent. On rocks or more rarely on trees.

Distributed throughout the northern United States, Alaska, and British America, especially in mountains. Known in all the grand divisions, but usually not extending into extreme arctic regions.

1a. *Parmelia perlata ciliata* (Lam. & DC.) Schaer. Enum. Lich. Eur. 34. 1850.*Lobaria perlata ciliata* Lam. & DC. Fl. Fr. ed. 3. 2: 403. 1805.

Thallus lobes as above or frequently more dissected, their margins and sometimes the upper surface black-ciliate and the surface frequently bearing soredia and isidioid growths.

Ours more densely rhizoid-bearing below than the type. Sterile.

A rare plant in the State, collected on Carlton Peak and at Rainy Lake City. On trees and mossy rocks. Also no. 362 from Gunflint referred to *Parmelia crinita* belongs here.

Little is known of the plant in America, but Nylander reports it from all of the grand divisions except Asia.

2. *Parmelia perforata* (Wulf.) Ach. Meth. Lich. 217. 1803.*Lichen perforatus* Wulf. in Jacq. Coll. Bot. 1: 116. 1786.

Thallus prostrate with ascendant margins, commonly orbicular in outline, the lobes rather large and somewhat imbricate, with rounded margins usually more or less crenate or irregular and ciliate, the upper surface sea-green or whitish and frequently rugose toward the center, beneath black or brownish black and usually brown toward the margin, bearing strong black rhizoids over the greater portion of the lower surface, usually large, 7.5 to 15 cm. in diameter; apothecia rather large, 2 to 12 mm. in diameter, subpedicellate, with chestnut disk, this deeply concave or even cyathiform, commonly perforate at the center, the margin entire or crenate; hypothecium pale or slightly yellowish; hymenium colorless below and brownish just below the epithecium; paraphyses commonly simple and slender, the apex usually brownish and thickened; asci clavate; spores oblong-ellipsoid, 9 to 14 μ long and 6 to 7.5 μ wide.

Collected at Taylors Falls on rocks and at Mankato on trees. A rare plant in Minnesota, but doubtless distributed quite generally over the southern half of the State. The doubtful plant recorded from Carlton Peak belongs to the subspecies above, though, as Tuckerman remarks, it is "quite as much at home in the present species."

Widely distributed in North America and known in all the grand divisions except Asia.

2a. *Parmelia perforata hypotropa* Nyl. Syn. Meth. Lich. 1: 378. 1858.

Thallus rather light sea-green above and pale or slightly brownish below, where it is clothed with white or slightly colored rhizoids, the upper surface and the margins somewhat sorediate, the margins not ciliate.

Sterile and on the whole appearing more like *Parmelia perlata* except for the pale color.

Once collected, at Grand Portage on rocks.

A strictly North American plant, reported from widely separate areas in the United States and Mexico.

3. *Parmelia cetrata* Ach. Syn. Meth. Lich. 198. 1814.

Thallus usually large, 8.5 to 16.5 cm. in diameter, prostrate, the lobes frequently crowded and much more ascendant than in the last, the margins of the lobes sometimes densely sorediate and, in ours at least, sometimes quite ciliate, rather thinner than the last and less inclined to become rugose toward the center, the upper surface light or darker sea-green, beneath black but usually brown toward the margin, clothed with rhizoids rather smaller than those of the last.

Ours sterile—fructed specimens not seen; apothecia and spores said to be like those of the last, of which Nylander regarded it as a subspecies.

A rare lichen in Minnesota. Two specimens were collected on rocks at Granite Falls. No. 513 from that place is undoubtedly this species, having the more ascendant, densely crowded, and strongly sorediate lobes. No. 514 is an intermediate form, quite as near the last species above.

Tuckerman gives the species a wide North American distribution, and it seems to be a strictly American lichen. Known in South America also.

4. *Parmelia crinita* Ach. Syn. Meth. Lich. 196. 1814.

Thallus usually large, 7.5 to 16 cm. in diameter, prostrate with slightly ascendant margin, densely beset with granules or isidioid branchlets, light or darker sea-green, the lobes rather large, rounded and frequently imbricate, their margins rather inconspicuously ciliate and entire, somewhat irregular or crenate, beneath black or rarely partly brown, usually of the latter color toward the margins, the lower surface clothed with rhizoids like those of the last species; apothecia subpedicellate, rare, those examined small (3 to 5 mm.), though Nylander gives 4 to 14 mm. in diameter, deeply concave, the disk chestnut, the margin crenate, irregular or isidioid, frequently ciliate; hypothecium pale or yellowish; hymenium pale below and brownish above; paraphyses simple, slender, the tips pale or yellowish and usually thickened; asci broadly clavate; spores simple, ellipsoid, their walls thick, 17 to 22 μ long and 9 to 15 μ wide.

Generally distributed over the State, but by no means common. On trees and rarely on rocks.

Distributed throughout the United States and Canada. Also known in South America, Europe, and Africa.

5. *Parmelia tiliacea* (Hoffm.) Ach. Meth. Lich. 215. 1803.

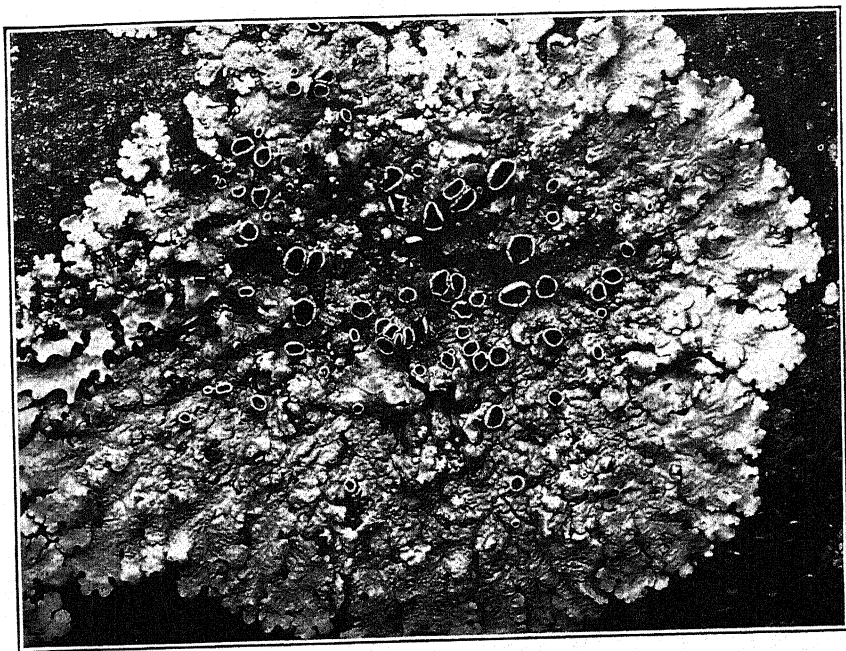
PLATE 36, A.

Lichen tiliaceus Hoffm. Enum. Lich. Icon. 26. pl. 16. f. 2. 1784.

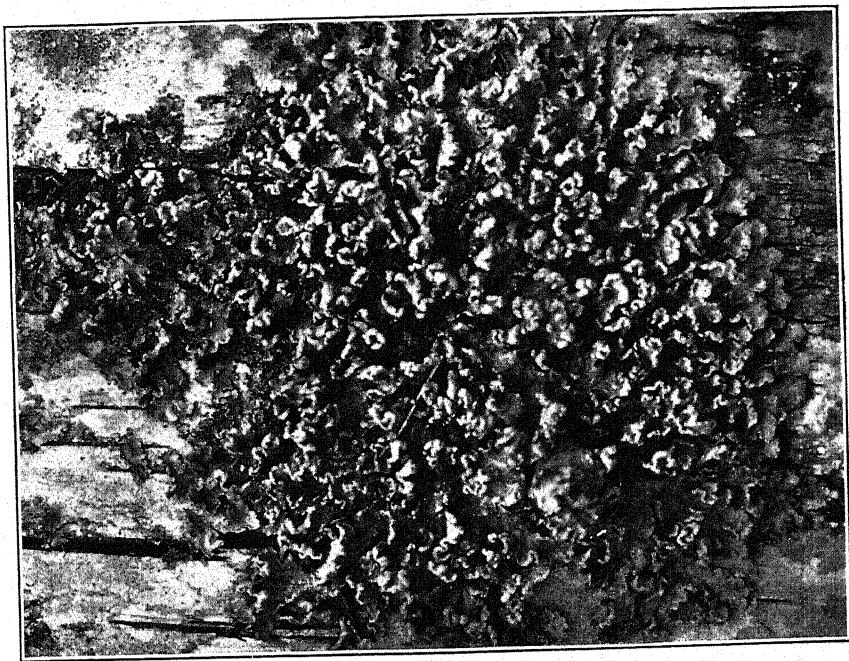
Thallus closely adnate, suborbicular in outline, rather small, 30 to 90 mm. in diameter, sea-green, the upper surface commonly rugose, especially toward the center, the lobes rather short and rounded, with crenate or irregularly divided margins or rarely elongated and subdichotomously divided, beneath black and densely covered with black rhizoids; apothecia sessile or subpedicellate, frequent and of medium size, 3 to 12 mm. in diameter, deeply concave or rarely nearly flat, the disk chestnut, the margin crenulate to crenate or rarely entire; hypothecium pale; hymenium pale or very slightly colored; paraphyses simple or rarely branched, slender, the apex pale or brownish and thickened; asci clavate; spores short-ellipsoid, 5 to 11 μ long and 5 to 7 μ wide.

Generally distributed over the State, but rare in the northeastern portion. On trees, old wood, and rocks.

A. *PARMELIA TILIAEAE* (HOFFM.) ACH.



B. *CETRARIA JUNIPERINA PINASTRI* (SCOP.) ACH.





PARMELIA SAXATILIS (L.) ACH. AND P. PHYSODES (L.) ACH.

Common throughout the United States, Alaska, and British America. Distributed in all of the grand divisions.

EXPLANATION OF PLATE 36.—A, Plant of *Parmelia tillicia* on a tree trunk, showing the closely attached foliose thallus and the sessile apothecia. B, Plant of *Cetraria juniperina pinastri* on birch bark, showing the crisped ascendant thallus lobes. A enlarged $1\frac{1}{2}$ diameters; B, $1\frac{1}{4}$ diameters.

6. *Parmelia borrieri* Turn. Trans. Linn. Soc. Lond. 9: 148. pl. 13. f. 2. 1808.

Thallus rather closely adnate with a sometimes free and slightly raised margin, rather large, 6 to 14.5 cm. in diameter, the upper surface sea-green or varying toward ashy or brownish, commonly rugose, rarely sorediate (more commonly so in European specimens), the margins rarely white-powdery, the lobes rather wider and shorter than in the next and usually cut crenate; lower surface ashy to pale brownish with white or darkening rhizoids; apothecia middle-sized to large, 3 to 14 mm. in diameter, loosely sessile, the disk chestnut and the margin entire, crenulate, or irregular, usually deeply concave or the smaller ones even cyathiform; hypothecium pale or brownish; hymenium pale or yellowish below and brownish above; paraphyses rather indistinct, but simple and slender, with tips usually brownish and thickened; asci clavate; spores ellipsoid, 10 to 16 μ long and 6 to 8.5 μ wide.

Widely distributed in the State, but scarcely common. Represented in the northeastern portion by the subspecies below. On trees and rarely on rocks.

Seems to be widely distributed in North America, though Tuckerman thought the first subspecies much more common and did not differentiate clearly as to distribution. Known in all the grand divisions except Australia.

6a. *Parmelia borrieri rudecta* (Ach.) Tuck. Syn. Lich. N. E. 26. 1848.

Parmelia rudecta Ach. Syn. Meth. Lich. 197. 1814.

Thallus covered with isidioid branchlets or rarely mere granules, on the whole rather lighter-colored than the above, rarely fruited, and when so the apothecia small, those seen not exceeding 3 or 4 mm. in diameter.

Distributed throughout the State, but not more common than the species. On trees and rarely on rocks; most common on cedars in swamps in the northern portion of the State.

Distributed throughout North America and found also in Australia.

7. *Parmelia saxatilis* (L.) Ach. Meth. Lich. 204. 1803.

PLATE 37.

Lichen saxatilis L. Sp. Pl. 1142. 1753.

Thallus rather less closely adnate than the last and smooth or obscurely rugose, becoming rimose, often bearing isidioid granules or branchlets, sea-green or ashy, the lobes commonly long and narrow and sinuate or subdichotomously branched, somewhat imbricate, rather smaller than the last, 6 to 13.5 cm. in diameter (but reaching 17.5 cm. in rare instances), beneath black, or brownish toward the margins, and clothed with black rhizoids; apothecia rarely present, middle-sized to large, 3 to 12 mm. in diameter, sessile or subsessile, the disk chestnut, the margin entire, crenulate or irregular, concave or the smaller ones cyathiform; hypothecium and hymenium pale or yellowish; paraphyses commonly simple and slender, the apices usually brownish and thickened; asci clavate; spores ellipsoid, 12 to 16 μ long and 8 to 10 μ wide.

Distributed throughout the State, but rarely fruited. On trees, old wood, and rocks. Best developed in northern Minnesota, where the plant is oftener found fruited.

Common in northern United States and northward, but rare southward. Known in all of the grand divisions.

EXPLANATION OF PLATE 37.—*Parmelia saxatilis* and *P. physodes* taking possession of an old balsam fir. At Grand Marais. About one-twelfth natural size.

7a. *Parmelia saxatilis sulcata* (Tayl.) Nyl. Syn. Lich. 1: 389. 1858.*Parmelia sulcata* Tayl. in Mack. Fl. Hibern. 2: 145. 1856.

Thallus usually wider lobed and paler and bearing rounded, oblong, or irregular soredia; apothecia seen smaller and spores also rather smaller.

Widely distributed in the State, but rare. On trees and rarely on rocks.

As widely distributed as the species in North America. Also common in northern Europe and Asia.

7b. *Parmelia saxatilis panniformis* (Ach.) Schaer. Lich. Helv. Spic. 10: 457. 1839.*Parmelia omphalodes panniformis* Ach. Meth. Lich. 204. 1803.

Tuckerman says "lobes short, densely crowded, and imbricated." Ours is small, but the lobes are not shorter in proportion to size, nor are they more imbricate than ordinarily. The plant is more closely adnate than usual and well supplied with isidioid granules or branchlets. The few apothecia were small and unfortunately yielded no spores.

Collected twice in southwestern Minnesota and several times along the northern boundary. On rocks.

Elsewhere in America known in the arctic region and in the White Mountains (New Hampshire). Also in Europe.

8. *Parmelia physodes* (L.) Ach. Meth. Lich. 250. 1803.

PLATE 37.

Lichen physodes L. Sp. Pl. 1194. 1753.

Thallus of medium size, 5.5 to 10 cm. in diameter, rather loosely attached to the substratum, showing open spaces between the lower cortex and the medullary layer (inflated), usually quite smooth, sea-green or whitish, the lobes long, narrow, sinuous or dichotomously branched, somewhat imbricate with the margins frequently somewhat ascendant; beneath black or brownish black, brown or white-sorediate toward the margins, rugose and without rhizoids; apothecia rather rare, middle-sized to large, 3 to 14 mm. in diameter (or reaching 18 or 20 mm. in material from Australia), inflated-subpedicellate, the disk chestnut or lighter, the margin entire or somewhat irregular, commonly more or less concave; hypothecium pale or brownish; hymenium pale or brownish; paraphyses plainly jointed, simple or rarely branched toward the sometimes thickened and colored apex; asci broadly-clavate; spores subspherical or short-ellipsoid, 4 to 8 μ long and 4 to 6 μ wide.

Common on trees in the northern portion of the State. Rarely on rocks also. Ours sterile and the microscopic characters taken from other material.

Widely distributed in North America and common to all of the grand divisions.

EXPLANATION OF PLATE 37.—See page 195.

9. *Parmelia pertusa* (Schränk.) Schaer. Lich. Helv. Spic. 10: 457. 1839.

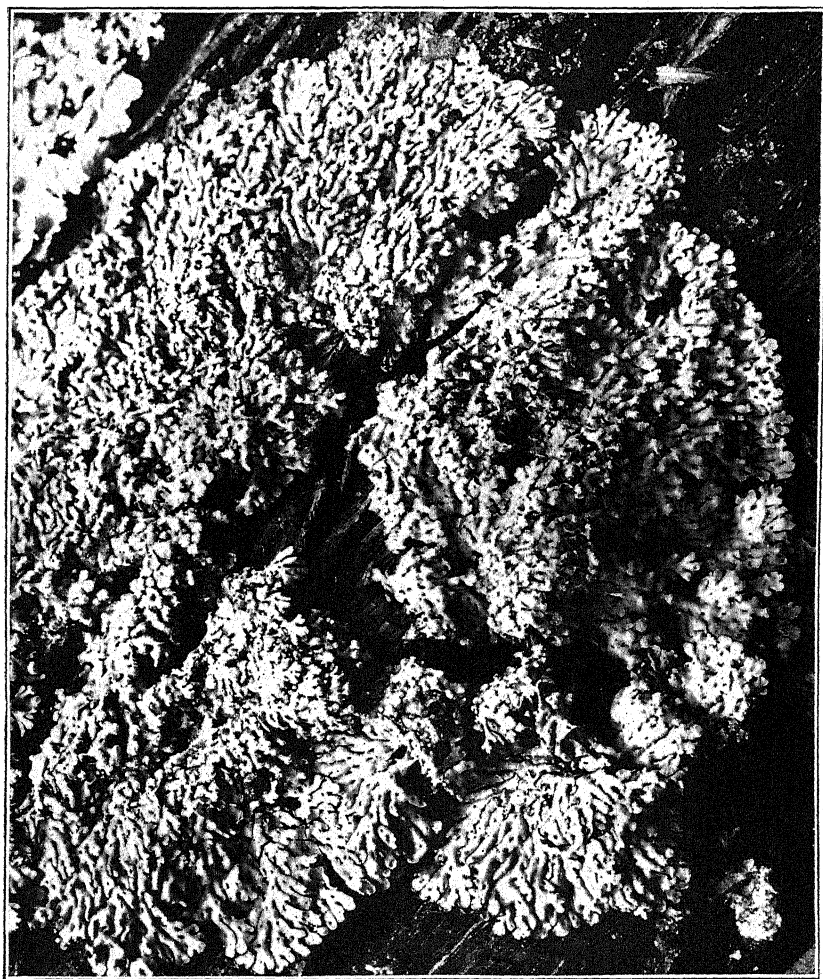
PLATE 38.

Lichen pertusus Schränk, Baier. Fl. 2: 519. 1789.

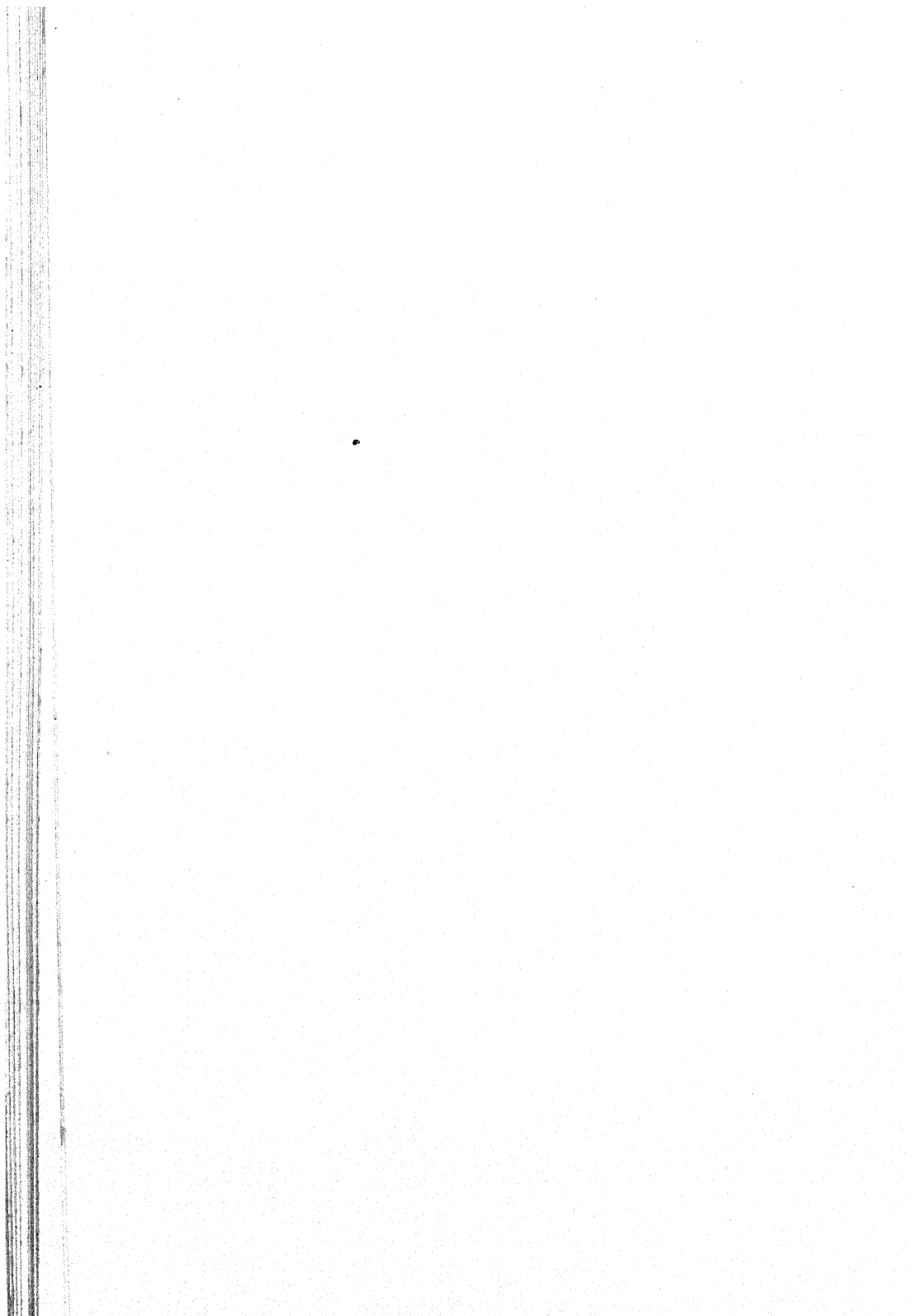
Thallus closely adnate, medium sized or larger, 6 to 15 cm. in diameter, showing open spaces between the lower cortex and the medullary layer (inflated), the surface shining and sea green or whitish, bearing scattered round white soredia and perforated sparingly by round or oblong holes (pertuse), the lobes crowded, imbricate, and freely branching, their margins scarcely ever ascendant; beneath black or brownish toward the margins, rugose and without rhizoids; apothecia very rare, small, the disk chestnut, the margin entire; spores 2 or 4 in each ascus, ellipsoid, 45 to 60 μ long and 22 to 28 μ wide.

Ours sterile and the apothecial and spore characters taken from Tuckerman.

Collected at Grand Marais (Hibbard photograph no. 5240). On cedars. Not known elsewhere in the State, and not previously reported.



PARMELIA PERTUSA (SCHRANK.) SCHAER.



According to Tuckerman confined for the most part to mountains and only reported by him in the mountains of New England. Has been reported from Ohio more recently and also from Alaska. Known in all of the grand divisions except Africa.

EXPLANATION OF PLATE 38.—Plant on a tree trunk, showing the pertuse foliose thallus. Natural size.

10. *Parmelia aleurites* Ach. Meth. Lich. 208. 1803.

Lichen aleurites Ach. Lich. Suec. 117. 1798.

Thallus rather small, 35 to 85 mm. in diameter or variously broken and spread over larger areas of the substratum, whitish or light sea-green, closely adnate, rugose and more or less sorediate, dark-colored and sparingly fibrillose below, the margin sometimes raised or ascending; apothecia chestnut-brown or chestnut-reddish, 1 to 3 mm. in diameter; spores oblong or oblong-fusiform, often curved, 11 to 12 μ long and 3 to 4 μ wide.

Ours sterile, the spore and apothecial characters taken from Nylander.

This is evidently the plant which Tuckerman did not distinguish from *Parmelia ambigua albescens* Wahl., but which Nylander recognized.^a Strangely enough *Cetraria aleurites* (Ach.) Th. Fr.^b can also be traced back to *Lichen aleurites* Ach. That two distinct plants are based on this plant of Acharius may be seen plainly by comparing *Cetraria aleurites* of Tuck.^c with *Parmelia aleurites* of Nylander's work cited above.

On trees at Minneapolis and on rocks at New Ulm.

Elsewhere in North America from Greenland. Known also in Europe.

11. *Parmelia olivacea* (L.) Ach. Meth. Lich. 213. 1803.

Lichen olivaceus L. Sp. Pl. 1143. 1753.

Thallus small or medium-sized, 20 to 80 mm. in diameter, closely adnate, the upper surface usually somewhat rugose and frequently bearing isidioid growths, pale or darker olivaceous, the lobes more or less radiate, frequently somewhat imbricate, more or less branched, their margins sinuate or obscurely crenate; beneath of the same color or more commonly black, bearing scattered brown or black rhizoids; apothecia small or middle-sized, 2 to 6 mm. in diameter, sessile or rarely subpedicellate, the disk chestnut or darker, the margin entire or crenulate, concave or rarely plane; hypothecium pale; hymenium pale or brownish, especially above; paraphyses simple and slender, the apex usually brownish and somewhat thickened; asci clavate; spores ellipsoid, 11 to 16 μ long and 7 to 9 μ wide.

Distributed throughout the State and common in the northern portion. On trees and old wood.

Common in the Northern States and northward; occurring farther south, but there confined mostly to mountains. Common in northern Europe and Asia and also found in northern Africa.

11a. *Parmelia olivacea aspidota* Ach. Meth. Lich. 214. 1803.

Thallus, and apothecia externally, thickly covered with minute verrucae of the same color; spores smaller, 7 to 9 μ long and 5 to 6 μ wide; paraphyses more distinct in the material examined. Otherwise the same microscopically.

Collected in the Leaf Hills near Vining. On trees. Doubtless occurs in other parts of the State.

North American distribution about the same as that of the species. Also occurs with the species in Europe.

^a Cf. Nyl. Not. Sällsk. Faun. Flor. Fenn. 5:105. 1861.

^b Lich. Scand. 1:109. 1871.

^c Syn. N. A. Lich. 1:32. 1882.

11b. *Parmelia olivacea proluxa* Ach. Meth. Lich. 214. 1803.

Thallus a dark olivaceous brown, on the whole rather better developed than that of the species, the lobes perhaps narrower, closely crowded and much imbricated, giving a rough surface above; spores smaller, 8 to 11 μ long and 5 to 6 μ wide. Ours scarcely shows as narrow lobes as we should expect from Tuckerman's brief statement, but agrees well with herbarium specimens from Europe.

Confined for the most part to the northern part of the State, though the plants from Granite Falls and New Ulm referred to *Pannaria olivacea pannariformis* Nyl.^a seem rather to belong here. On rocks.

Occurs in the mountains, both eastern and western, and descends to the north. Also found in northern Europe and Asia.

12. *Parmelia conspurcata* (Schaer.) Wainio, Medd. Soc. Faun. Flor. Fenn. 14: 22. 1888.

Parmelia olivacea corticola conspurcata Schaer. Lich. Helv. Spic. 10: 466. 1840.

Thallus larger than in the last species (3 to 10 cm. in diameter), less closely adnate, the upper surface olivaceous, more or less rugose, usually somewhat covered with commonly whitening isidioid growths or with soredia of the same color, the lobes wider and less elongated, with sinuous or crenate somewhat ascendant, rarely white-powdery margins, beneath black or brownish black, brown toward the margin, and bearing rhizoids of the same colors; apothecia not seen.

Frequent in the northern portion of the State. On trees and rarely on rocks. Number 131 from Minneapolis and number 60 from Taylors Falls, both referred to *Parmelia olivacea*, also belong here. The writer has collected the same at Concord, Massachusetts, and has a specimen from Fayette, Iowa, which seems to be the same. Nothing further is known of its North American distribution. Evidently not the same as *Parmelia olivacea sorediata* (Ach.) Nyl.,^b which is recorded in Tuckerman's Synopsis. The species is well known in Europe.

13. *Parmelia caperata* (L.) Ach. Meth. Lich. 216. 1803.

Lichen caperatus L. Sp. Pl. 1147. 1753.

Thallus medium-sized or large, 5 to 22.5 cm. in diameter, prostrate with margins frequently somewhat ascendant, the central portions most frequently quite entire and the marginal portions only shortly lobed, or the central portions as well composed of somewhat imbricated lobes, the upper surface undulate, commonly somewhat rugose, and usually isidioid or sorediate, the margins of the lobes incised, crenate, or subentire; straw-colored varying to yellowish or whitish, beneath black with rather scattered rhizoids of the same color, the margins, however, brown and the rhizoids there frequently light-colored; apothecia rare, sessile, middle-sized, 3 to 12 mm. in diameter, the disk chestnut, concave, the margin crenulate or subentire and frequently sorediate or isidioid; hypothecium pale or yellowish; hymenium pale or yellowish below and usually brownish above; paraphyses commonly simple, distinct, the tips slightly enlarged and sometimes brownish; asci clavate; spores ellipsoid, 15 to 20 μ long and 7 to 10 μ wide.

Occurs in all parts of the State, sterile except in the northern portion, where the plant is occasionally fruited. On trees, old wood, and stones.

Distributed throughout North America. Common to all of the grand divisions.

14. *Parmelia conspersa* (Ehrh.) Ach. Meth. Lich. 205. 1803.

Lichen conspersus Ehrh.; Ach. Lich. Suec. 118. 1798.

Thallus prostrate, medium-sized or larger, 5 to 15 cm. in diameter, the upper surface smooth or subrugose, the lobes long and rather narrow, crowded and imbricate, with sinuate or crenate margins, the upper surface often sorediate or isidioid toward the center, straw-colored, usually varying toward greenish or yellowish, the

^a Lich. Scand. 102. 1861.

^b Not. Sällsk. Faun. Flor. Fenn. 5: 102. 1861.

lobes frequently closely imbricated toward the center and forming a continuous crust; beneath varying from pale brownish to black and when black having brown margins; rhizoids usually present and of the same color as the lower surface; apothecia common, sessile, middle-sized, 3 to 11 mm. in diameter, the disk chestnut, concave, the margin crenulate or subentire; hypothecium pale or slightly colored; hymenium pale below and pale or brownish above; paraphyses commonly simple, somewhat thickened, and frequently brownish toward the apex; asci clavate; spores ellipsoid, 8 to 11 μ long and 4.5 to 7 μ wide.

Occurs in all portions of the State. On igneous or metamorphic rocks, and rarely on wood.

Common throughout the northern States, Alaska, and British America and farther south in mountains. Distributed in all of the grand divisions.

15. *Parmelia centrifuga* (L.) Ach. Meth. Lich. 206. 1803.

Lichen centrifugus L. Sp. Pl. 1142. 1753.

Thallus in ours rather small, 3 to 6.5 cm. in diameter, but in European specimens reaching 10 cm., prostrate, composed of narrow, elongated, convex, crowded, and imbricated, centrally more or less rugose-plicate lobes, the central crust thus formed frequently falling away and leaving only the concentrically arranged periphery, straw-colored varying from greenish to yellowish; margins of the lobes sinuous, crenate, or incised; under surface whitish with darker rhizoids; apothecia small, in American and European specimens seen 2 to 3 mm. in diameter, said, however, to be middle-sized, sessile, the disk chestnut, concave, the margin subcrenulate; hypothecium pale or yellowish; hymenium pale below and pale or brownish above; paraphyses quite distinct, plainly jointed, commonly simple, somewhat thickened at the brownish apex; asci clavate; spores ellipsoid, 7 to 10 μ long and 4.5 to 5.5 μ wide.

Ours sterile and the apothecial and spore characters taken from other material.

Once collected on rocks in the Misquah Hills.

Commonly confined to arctic or subarctic regions or to mountains, but found by Agassiz on the north shore of Lake Superior. In northern Europe and Asia as well as in North America.

***CETRARIA* Ach. Meth. Lich. 292. pl. 5. f. 3. 1803.**

The thallus is usually more or less ascendant. It may be either fruticose or foliose, and when the former it may be cylindrico-compressed or more or less channeled. The strictly fruticose forms are usually alpine, and our Minnesota species, except *Cetraria islandica*, are foliose, and closely adnate or more or less ascendant. In *Cetraria islandica* there is, as in the more foliose and prostrate forms, a well-developed cellular cortex on all sides; but in this species the algal layer is more scattered than usual in ours, being diffused throughout the medullary tissue or forming interrupted layers beneath the cortex on both sides of the thallus, while in our other species the algal cells are to be found in a definite layer just below the upper cortex. The thallus varies greatly in color.

The apothecia are disk-shaped or somewhat irregular in form, sessile and subpedicellate, terminal or marginal on the thallus, the disk differing from the thallus in color. The paraphyses and asci are rather short, composing a rather thin hymenium.

The spores are hyaline, simple, rather small, subellipsoid to subspherical in form.

Through the more erect forms the genus shows a close relationship to *Evernia* and indirectly with *Usnea*, while through the more foliose, less ascendant species the relationship with *Parmelia* is close.

Cetraria is represented in Minnesota by six species, of which *Cetraria ciliaris* is the only one generally distributed over the State.

The plants occur on trees, old wood, rocks, and earth.

Type species *Cetraria lacunosa* Ach. loc. cit.

KEY TO THE SPECIES.

- Thallus becoming fruticose..... 1. *C. islandica*.
 Thallus foliose.
 Thallus usually straw-colored or greenish.
 Thallus straw-colored, varying toward sea-green; whitish below..... 5. *C. aurescens*.
 Thallus scarcely varying from straw-colored above; yellowish below..... 6. *C. juniperina pinastri*.
 Thallus neither straw-colored nor greenish.
 Thallus large, reaching 90 mm. in diameter.
 Thallus becoming brownish, inconspicuously lacunose; margins ciliate..... 2. *C. ciliaris*.
 Thallus sea-green, conspicuously lacunose; margins not ciliate..... 4. *C. lacunosa*.
 Thallus small; not surpassing 15 mm. in diameter..... 3. *C. saepincola*.

1. *Cetraria islandica* (L.) Ach. Meth. Lich. 293. 1803.

Lichen islandicus L. Sp. Pl. 1145. 1753.

Thallus tufted, fruticose and subfoliose, rigid, variously lacinate, longitudinally grooved (canalicate) or the margins here and there connivent or even uniting, bearing cilia or spinules at the margins, and more or less covered with impressed white soredia on the outer side of the longitudinal furrows, shining, pale chestnut to olivaceous or brown toward the top and frequently paler or sanguineous toward the base, 3 to 8 cm. in length in ours (foreign specimens in the writer's herbarium reaching 12 cm.); apothecia reaching 1.5 to 14 mm., sessile at the tips of the lobes, the thalloid margin entire or crenulate, thin or disappearing, the disk brown or chestnut, concave, flat, convex or irregular; hypothecium pale or pale brownish; hymenium brownish above and pale or brownish within; paraphyses usually simple, brownish and somewhat thickened toward the apex; asci cylindrical to cylindrico-clavate; spores oblong-ellipsoid, 6 to 10 μ long, 3.5 to 5 μ wide.

Once recorded for the State from the palisades on the north shore of Lake Superior, where it occurs on humus over rocks. Noted in a depauperate condition on old wood at Grand Portage in 1902. Common on Isle Royale. The soredia are absent in the specimen in the writer's herbarium from Minnesota, but are present in much of the material from Isle Royale. Agassiz and Macoun have both found the subspecies *Cetraria islandica delisei* Schaer.^a along the north shore of Lake Superior, and it may well be looked for in Minnesota. The writer has also a specimen of the species collected by Parry in Minnesota or Wisconsin in 1848.

Distributed throughout all the grand divisions except possibly Africa. Common in frigid regions and reaching warmer territory in mountains or along cold coasts. More or less common in such regions in North America.^b

2. *Cetraria ciliaris* Ach. Lich. Univ. 508. 1810.

Thallus foliose, 25 to 90 mm. in diameter, sinuously or laciniately lobed, the lobes crowded and ascendant, often narrow and many-cleft, more or less lacunose, their margin crenate and bearing scattered cilia or fibrils; sea-green to brownish above, more or less fibrillose and of the same color or lighter beneath; apothecia reaching good size, 1.5 to 12 mm. or more in diameter, sessile on the margins of the lobes, commonly more or less concave, the disk chestnut-brown or paler, the margin crenulate; hypothecium pale; hymenium brownish above and pale or brownish below; paraphyses simple or branched, somewhat thickened and frequently brownish toward the apex; asci cylindrico-clavate; spores subspherical, 5 to 7 μ long and 4 to 5 μ wide.

^a Enum. Lich. Eur. 15. 1850.

^b The "Iceland moss." See p. 35.

Occurs in all parts of the State; common in the northern part but rare southward. On trees, occasionally on old wood, and once on sandstone.

The plant occurs throughout the United States, and also northward, but usually in a dwarfed condition tending toward the next species. The species is strictly American, having been sent to Acharius by Muhlenberg. Nylander records it from Peru; otherwise only known in North America.

3. *Cetraria saepincola* (Ehrh.) Ach. Meth. Lich. 297. 1803.

Lichen saepincola Ehrh. Hannover. Mag. 206. 1787.

Thallus foliose, small, scarcely exceeding 5 to 15 mm. in diameter (the plants usually densely clustered along small twigs, the limits of individual plants thus difficult to determine), the lobes few and short, prostrate or somewhat ascending, smooth or more or less rugose, their margins undulate, crenate, or incised; olivaceous or brown above and paler beneath, without fibrils; apothecia rather small, 0.7 to 4 or possibly 5 mm. in diameter, sessile on the margins of the lobes, frequently numerous and almost completely obscuring the small lobes, the disk of the same color as the thallus or darker brown, usually concave, the thalloid margin entire or crenulate and usually disappearing; hypothecium pale; hymenium brownish above and gradually becoming pale or paler brownish beneath; paraphyses conspicuously jointed, simple or branched, pale or brownish, and usually thickened toward the apex; asci cylindrico-clavate; spores short-ellipsoid, 7 to 9.5 μ long and 4 to 6 μ wide.

Once collected in the State, along the shore of South Fowl Lake, on the northern boundary. Also found on Isle Royale in 1902. On small twigs.

Essentially an arctic plant, occurring in the northern portions of North America, and farther south in mountains and along cold shores. Also reported from the extreme southern portion of South America and in northern Europe and Asia.

4. *Cetraria lacunosa* Ach. Meth. Lich. 295. pl. 5. f. 3. 1803.

Thallus foliose, middle-sized or large, 5 to 14 cm. in diameter, the lobes crowded, quite wide and rounded, ascending, with crenate or lacerate margins, sea-green and reticulate-lacunose above, lighter-colored or sometimes blackening beneath, without marginal cilia; apothecia often quite numerous, reaching good size, 1 to 10 mm. in diameter, sessile or subpedicellate on the margins of the lobes, frequently perforate at the center, the perforation extending through the thallus lobe also, the disk chestnut-brown, concave, with a thin entire thalloid margin which sometimes finally disappears; hypothecium pale; hymenium brownish above and gradually becoming paler within; paraphyses simple or branched, pale or brownish, frequently somewhat thickened toward the apex; asci clavate or cylindrico-clavate; spores short, oblong-ellipsoid, 5 to 8 μ long and 4 to 5 μ wide.

Common in the northern part of the State, but not known to exist in the southern half or two-thirds. On trees.

The plant is strictly North American and is common on trees and rails in the northern half of the United States, and found also in British America, Alaska, and farther south in the mountains. Not known to be confined to especially cold regions, though its distribution in Minnesota would seem to indicate this, it being especially common in the northeastern portion of the State. This distribution would seem to indicate that our plant might be the closely related *Cetraria glauca* (L.) Ach., though its characters are plainly those of the present species.

5. *Cetraria aurescens* Tuck. Syn. Lich. N. E. 16. 1848.

Thallus foliose, middle-sized or smaller, 15 to 60 mm. in diameter, the surface quite smooth, sinuously or laciniately lobed, the lobes many-cleft, the ascendant margins crisped; straw-colored varying toward sea-green above, beneath whitish and clothed more or less with whitish or pale brownish fibrils; apothecia of good size, 1 to 7 mm. in

diameter, subpedicellate on the margins of the lobes, the disk brown, concave, the thalloid margin crenulate, rarely disappearing; hypothecium pale; hymenium pale or brownish above and pale below; paraphyses simple or rarely branched, with conspicuous joints, the apex brownish and somewhat thickened; asci clavate; spores short-oblong or subspherical, 4 to 5.5 μ long and 3 to 4 μ wide.

Widely distributed in northern Minnesota, though rather rare. Along the shore of Lake Superior, extending as far south as Duluth, where it was collected by Anna M. Kimball. On conifers, especially cedars.

A North American plant and, outside of Minnesota, only known in the eastern United States.

6. *Cetraria juniperina pinastri* (Scop.) Ach. Meth. Lich. 298. 1803. PLATE 36, B.
Lichen pinastri Scop. Fl. Carn. ed. 2. 2: 382. 1772.

Thallus foliose, small or middle-sized, 15 to 80 mm. in diameter, with crowded, more or less lacunose, crisped, erose-crenate, ascendant lobes; greenish to straw-colored above and pale yellow below, sometimes bright yellow toward the margins of the lobes, these clothed more or less with bright yellow soredia; apothecia middle-sized, 2 to 6.5 mm. in diameter; hypothecium pale; hymenium pale or brownish above and pale beneath; paraphyses commonly simple, the apex pale or brownish, and usually thickened; asci clavate; spores short-ellipsoid or subspherical, 5 to 7.5 by 4 to 5.5 μ .

In the fruited specimen of the species from which the above macroscopic characters were taken, the apothecia are submarginal and subpedicellate, the disk chestnut-brown, and the thalloid margin crenulate. The plant examined microscopically was from Natick, Massachusetts, collected by Clara E. Cummings.

Quite common in the northern part of the State. On trees, old wood, and rarely on rocks.

The species is common in the eastern United States and occurs along the west coast. Also found in British America and Alaska. The subspecies is alpine and descending. Occurs most commonly in our mountainous regions, both eastern and western. Also occurs in northern Europe and Asia and farther south in mountains.

EXPLANATION OF PLATE 36.—See page 195.

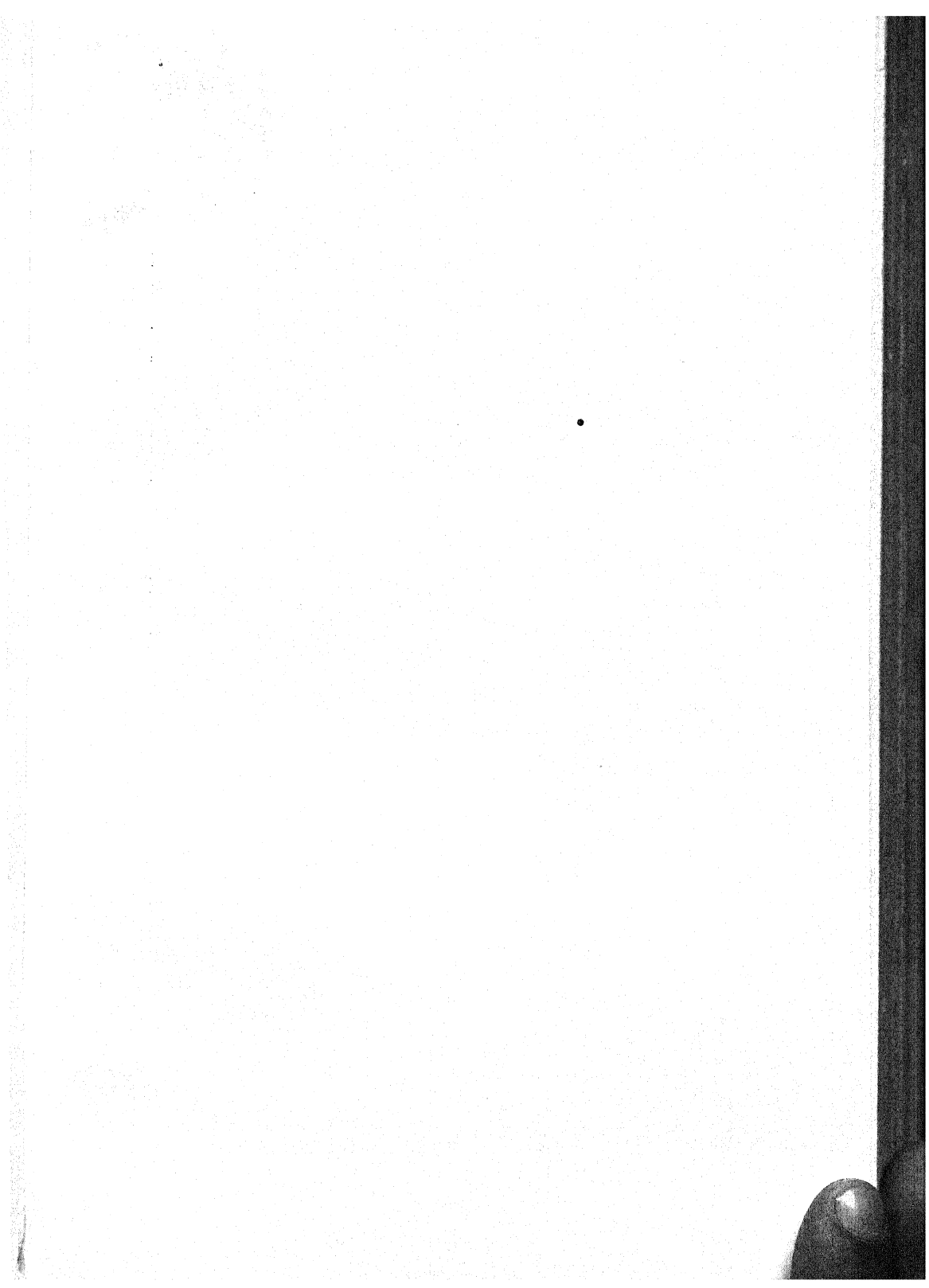
EVERNIA Ach. Lich. Univ. 84, 441. pl. 10. f. 1-3. 1810.

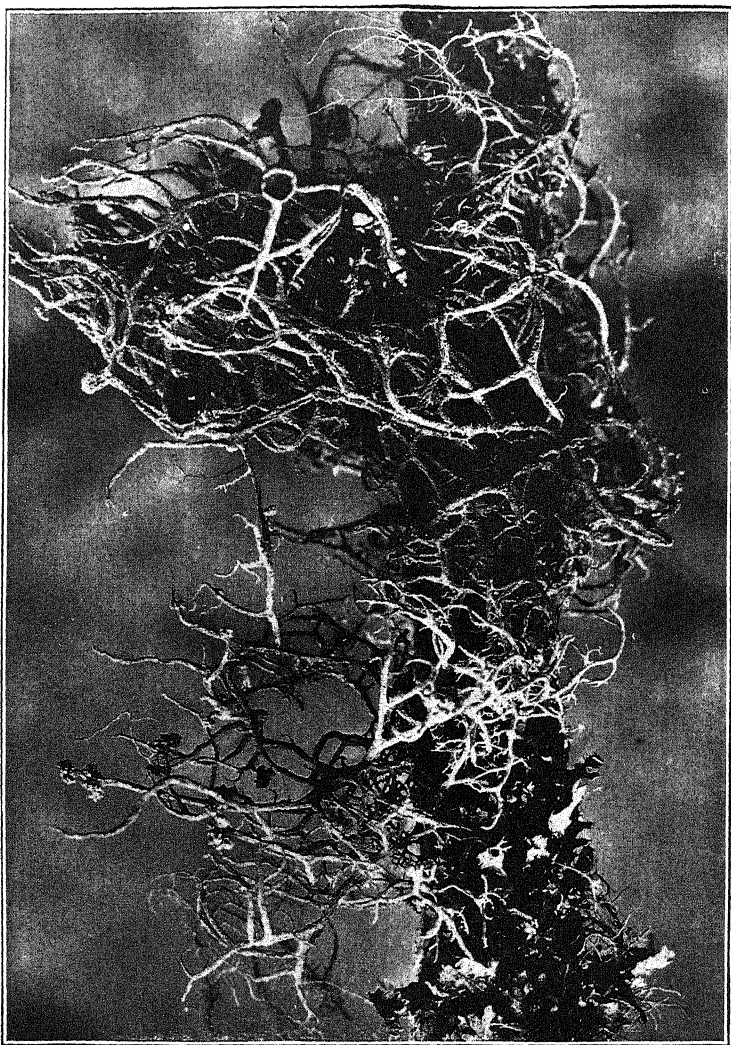
The thallus is more strictly fruticose than that of the more foliose *Cetrarias*, with which the genus is more or less closely related. Some of the species show a tendency toward a cylindrical form of thallus with radial arrangement of tissue layers. Branching is often dichotomous, and the thallus does not show the shining surface so characteristic of *Cetrarias*. The outer pseudocortex consists of an irregular network of hyphæ, which commonly extends vertical to the surface. Inside of this layer is the algal layer, consisting of rather large cells. Next within the algal layer lies the medullary layer, composed of loosely interwoven hyphæ and frequently hollow toward the center of the thallus. Within the medullary tissue lie closely packed longitudinal hyphæ in the form of a more or less complete hollow cylinder or forming a number of bundles. This cylinder of longitudinal hyphæ, or the bundles which replace it in some species, may be entirely wanting. The color is sea-green or yellow.

The apothecia are orbicular, large, and commonly terminal or subterminal with thalloid margin, the disk concave and of a color differing from that of the thallus. The hypothecium is pale and consists of two layers. The hymenium, in ours at least, is brownish above and pale or pale brownish below. The spores are hyaline, simple, more or less ellipsoid.

Only two species are certainly known in the State, though a third, *Evernia vulpina* (L.) Ach.,^a was collected in Minnesota or Wisconsin in 1848 by C. C. Parry.

^aLich. Univ. 443. 1810.





EVERNIA PRUNASTRI (L.) ACH.

The plants occur on trees, old wood, and rarely on rocks.

Type species *Evernia prunastri* (L.) Ach. loc. cit.

KEY TO THE SPECIES.

Thallus commonly sorediate and frequently isidioid, pale below. . . 2. *E. prunastri*.
Thallus not sorediate, but usually softish isidioid (furfuraceous),
for the most part black or black-spotted below..... 1. *E. furfuracea*.

1. *Evernia furfuracea* (L.) Mann. Lich. Bohem. 105. 1826.

Lichen furfuraceus L. Sp. Pl. 1146. 1753.

Thallus fruticose or subfoliose, 15 to 60 mm. long in our Minnesota specimens, though the species is frequently much longer, ascending, prostrate or pendulous, compressed, dichotomously and subpinnately lobed, the lobes tufted and frequently long, usually covered more or less with soft isidioid branchlets or tubercles above (furfuraceous), commonly channeled and lacunose below; sea-green to grayish above, beneath whitish, black-spotted or for most part black; apothecia rather large, 2 to 12 mm. in diameter, frequently short-pedicellate, terminal or lateral, disk deeply concave and brown, the margin usually entire but somewhat irregular; hypothecium pale; hymenium brownish above, pale brownish or pale below; paraphyses simple or rarely branched, with apex pale and scarcely thickened; asci clavate; spores 6.5 to 7.5 μ long and 4 to 5 μ wide, oblong-ellipsoid.

Occurring rarely in the northeastern portion of the State. On cedars. Ours sterile.

The species occurs in the northern United States and Canada and southward in the mountains. Also reported from Florida by Calkins. Known in cold portions of all the grand divisions except Australia.

2. *Evernia prunastri* (L.) Ach. Lich. Univ. 442. pl. 10. f. 1. 1810. PLATE 39.

Lichen prunastri L. Sp. Pl. 1147. 1753.

Thallus fruticose, tufted, ascending, prostrate, or long and pendent, rounded, somewhat angular or flattened, sometimes channeled below, much branched dichotomously and divaricately, the branches sometimes becoming long, lacunose, commonly more or less sorediate and frequently bearing isidioid branchlets, straw-colored to pale sea-green or paler below, 15 to 85 mm. long; apothecia of medium size in the two fruited specimens from the State, 4 to 8 mm. in diameter, sessile or subpedicellate on the margins of the branches, concave, the disk brown and the thalloid margin entire; hypothecium pale; hymenium brownish above and pale brownish below; paraphyses simple or possibly rarely branched, apex pale and scarcely thickened; asci clavate; spores ellipsoid, 5.5 to 7 μ long and 3 to 4 μ wide.

Generally distributed over the State, but hardly common. On trees, old wood, and rarely on rocks. Found fruited but twice.

Occurs throughout the northern United States and British America. The plant is known in all the grand divisions except, possibly, Australia.

EXPLANATION OF PLATE 39.—Plant on the limb of a tree showing the fruticose thallus and the very rare apothecia. Natural size.

RAMALINA Ach. Lich. Univ. 122, 598. pl. 13. f. 5-11. 1810.

PLATE 40.

The thallus is fruticose and flattened. The pseudocortex consists of closely packed hyphæ, extending wholly or for the most part in the direction of the long axis of the thallus. The medullary portion consists of loosely interwoven hyphæ which, in some species, run mostly in the direction of the long axis of the thallus and are seldom united with the cortical hyphæ, while in other species (all of ours) they run in various directions and are commonly united with the cortical hyphæ. The algal layer extends around wholly within the cortex in the form of a hollow flattened cylinder.

The apothecia are upon one side of the thallus (upper when the branches are not erect), along the margin or terminal or subterminal, subpedicellate, with entire

thalloid exciple, the disk pale, the hypothecium pale, the hymenium of the same color or tinged with brown. The hypothecium consists of two layers. The spores are hyaline, oblong to ellipsoid, and 2-celled.

The phyletic relations of the genus are by no means known. In superficial appearance the plants are perhaps most like those of the genus *Roccella*, but the two genera are not closely related anatomically. Morphologically *Ramalina* is much more closely related to *Usnea* and *Evernia*.

The genus is represented in Minnesota by seven quite distinct forms. *Ramalina calicaris*, in some of its forms, is the most common species in the State, through *Ramalina pusilla* is common enough in the northern portion.

Ramalinas may be looked for on trees, old wood, and rocks.

Type species *Ramalina homalea* Ach. loc. cit.

EXPLANATION OF PLATE 40.—Fig. 1, the plant, showing the lobed thallus and the apothecia. Fig. 2, a portion of the thallus and three apothecia. Fig. 3, a section through an apothecium and the thallus below; *a*, the hymenium; *b* and *c*, the hypothecium; *d*, the algal layer; *e*, the medullary layer; *f*, the algal layer; *g*, the pseudocortex of entangled hyphæ. Fig. 4, a longitudinal section of the thallus; *a* and *f*, the pseudocortex; *b* and *c*, the algal layer; *c* and *d*, the medullary layer. Fig. 5, paraphyses and an ascus. Fig. 6, two-celled spores. Fig. 7, algal cells. Fig. 1, natural size; fig. 2, enlarged about 10 diameters; figs. 3, 4, enlarged 400 diameters; figs. 5-7, enlarged 650 diameters. From Schneider.

KEY TO THE SPECIES.

Thallus neither sorediate nor hollow within (inflated).

Thallus much branched, the lobes narrow.

Thallus lobes conspicuously canaliculate..... 1b. *R. calicaris canaliculata*.

Thallus lobes not canaliculate..... 1. *R. calicaris*.

Thallus less branched, the lobes wider..... 1a. *R. calicaris fraxinea*.

Thallus lobes either sorediate or inflated.

Thallus lobes sorediate.

Thallus lobes sorediate throughout..... 1c. *R. calicaris farinacea*.

Thallus lobes sorediate especially toward the tips..... 2. *R. polymorpha*.

Thallus lobes inflated.

Tips of the lobes deflexed..... 3a. *R. pusilla geniculata*.

Tips of the lobes not deflexed..... 3. *R. pusilla*.

1. *Ramalina calicaris* (L.) Fr. Lich. Eur. 30. 1831.

PLATE 41, A.

Lichen calicaris L. Sp. Pl. 1146. 1753.

Thallus 5 to 60 mm. long, somewhat rigid, composed of tufted lobes, compressed, usually more or less lacunose, the lobes numerous and crowded, narrow and dichotomously branched above, gray to sea-green; apothecia 1 to 6 mm. in diameter, depressed-flattish, subpedicellate, lateral, terminal or lateral near the apex, sea-green to flesh-colored; paraphyses more or less branched, pale and slightly thickened at the apex; asci clavate; spores oblong to ellipsoid, straight or slightly curved, 9 to 18 μ long and 4 to 7 μ wide.

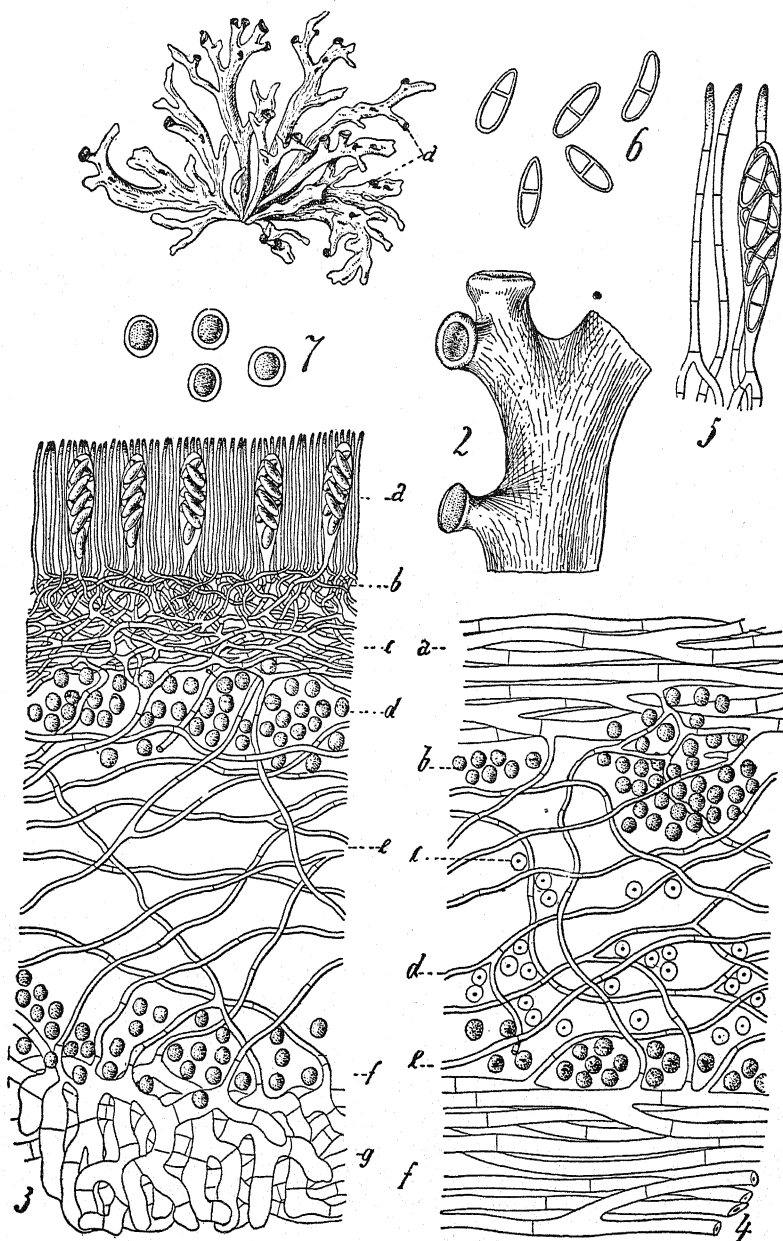
Frequent throughout the State. On trees, old wood, and rarely on rocks.

Ramalina calicaris fastigiata of the preliminary reports.

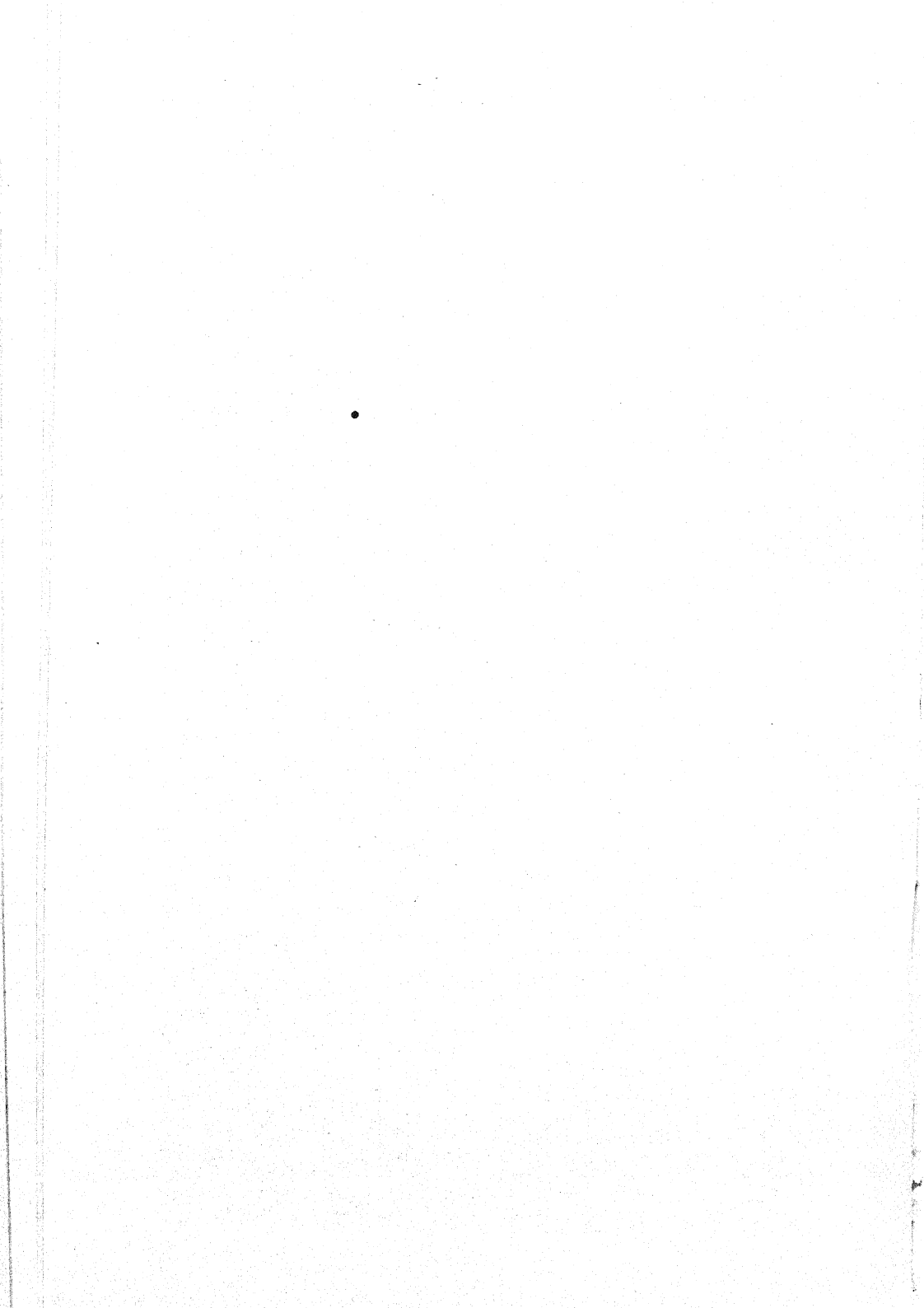
EXPLANATION OF PLATE 41.—A, Plants of *Ramalina calicaris* on the limb of a tree showing the foliose thallus and the apothecia. B, Plant of *R. pusilla*, rapidly replacing *Lecanoras* and *Biatoras* on the limb of a balsam fir. A natural size; B enlarged 2 diameters.

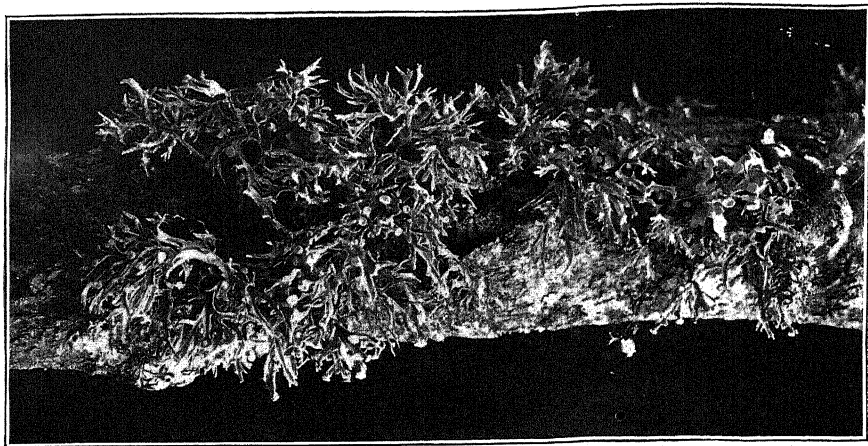
1a. *Ramalina calicaris fraxinea* (L.) Fr. Lich. Eur. 30. 1831.

Lichen fraxineus L. Sp. Pl. 1146. 1753.



RAMALINA CALICARIS (L.) FR.

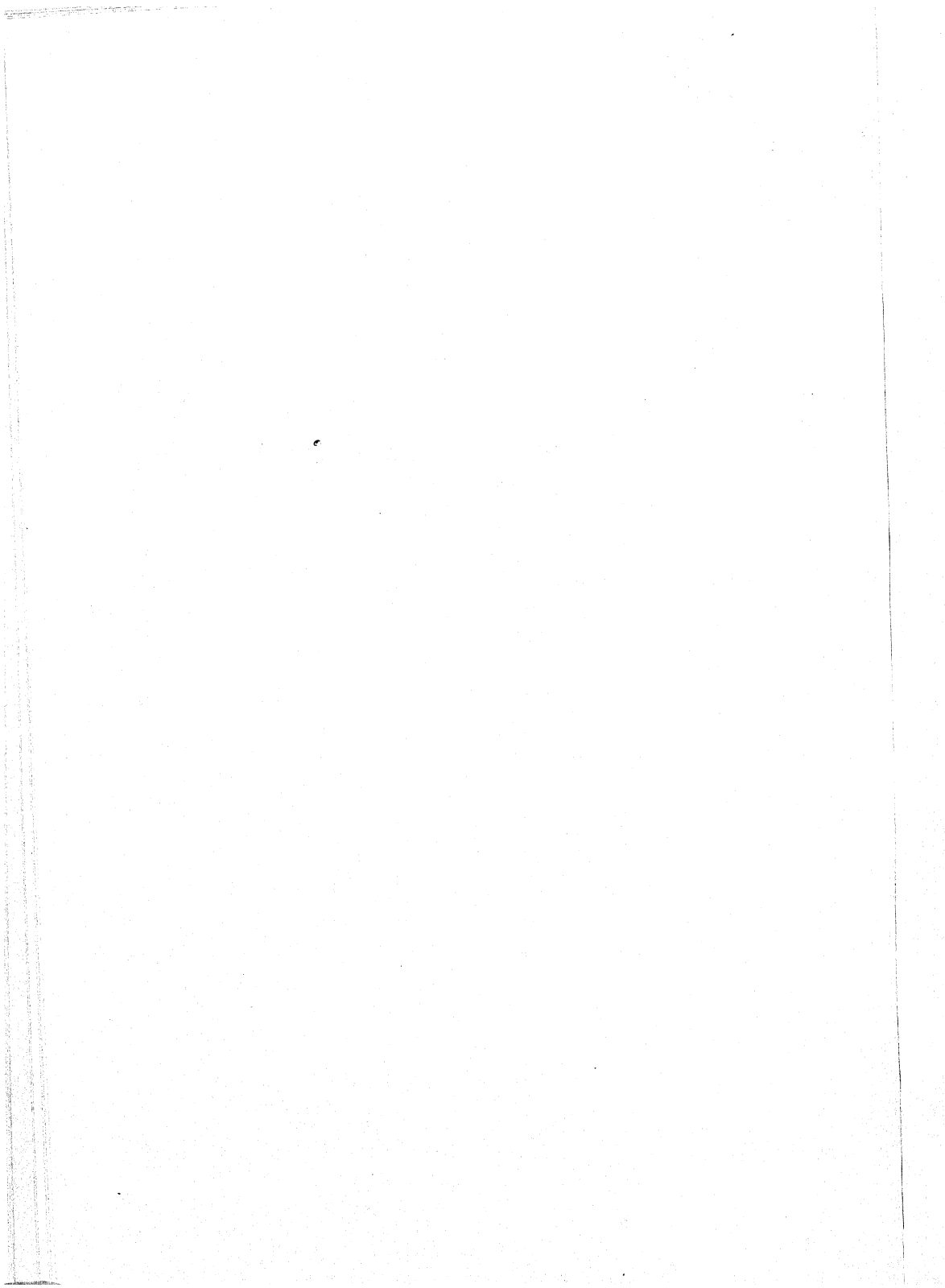




A. RAMALINA CALICARIS (L.) FR.



B. RAMALINA PUSILLA PREV.



Lobes few and wide, subsimple and frequently quite long; apothecia in the more distinct wide-lobed forms laterally placed on one side of the thallus and frequently larger than in other subspecies, sometimes surpassing the measurements given above. Extreme forms quite distinct, but passing into the next subspecies.

Occurs in all parts of the State except the northeastern portion, but is rare except in the southeastern part. On trees and old wood.

Widely distributed in North America. Also common in all the grand divisions except Australia. Foreign specimens sometimes twice as long as our Minnesota plants.

1b. *Ramalina calicaris canaliculata* Fr. Lich. Eur. 30. 1831.

The lobes much as in the last as to number, branching, and length, but even narrower and with a conspicuous longitudinal groove on one side (canaliculate); apothecia of the same size as in the last above, but attached just below the usually long and geniculate tips.

A single locality in the State, Snowbank Lake, in the extreme northern part. On trees.

American and foreign distribution about the same as that of the last, but the plant is more rare in most localities.

1c. *Ramalina calicaris farinacea* (L.) Nyl. Act. Soc. Linn. Bord. 21: 293. 1856.

Lichen farinaceus L. Sp. Pl. 1146. 1753.

Thallus lobes frequently narrower than in the last, usually smoother, frequently becoming quite long and slender, covered more or less with usually conspicuous white soredia; apothecia lateral or terminal, rare.

Occurs in all parts of the State, but is rarely seen in fruit. On rocks and rarely on trees.

Common to all the grand divisions, both in frigid and warmer regions. The plant frequently reaches 12 to 14 cm. in length in Europe.

2. *Ramalina polymorpha* Ach. Lich. Univ. 600. 1810.

Lichen polymorphus Ach. Vet. Akad. Handl. 18: 270. pl. 11. f. 3. 1797.

Thallus 10 to 40 mm. long, somewhat rigid, smooth or longitudinally rugose, composed of tufted lobes, compressed; lobes few or many, narrow (in ours scarcely more than 2 to 4 mm. wide) and sprinkled more or less, especially toward the apices, with conspicuous soredia; apothecia 2 to 5 mm. in diameter, slightly concave, pale yellowish or more or less white-pruinose, subpedicellate and subterminal; paraphyses somewhat branched or simple, the apex slightly thickened but scarcely colored; asci cylindrico-clavate; spores oblong, straight, 11 to 15 μ long and 4 to 5 μ wide.

The above microscopic characters were taken from European plants and from number 763 collected in 1897 at the Palisades, north shore of Lake Superior.

The plant from the Palisades is the only undoubted specimen of the species collected thus far in Minnesota. Others from Granite Falls and Rainy Lake City seem nearer the last above. On rocks.

Little is known of the plant in North America. More or less common in Europe, Africa, and Australia.

3. *Ramalina pusilla* Prev. in Fr. Lich. Eur. 29. 1831.

PLATE 41, B.

Thallus small, about 7 to 13 mm. long, somewhat rigid, smooth or more or less reticulated, composed of tufted lobes, these rounded or compressed, hollow-inflated, only 1 to 2 mm. wide; apothecia small, 0.5 to 2 mm. in diameter, plane or somewhat concave, pale yellowish or whitish, sessile or subpedicellate, commonly subterminal; paraphyses more or less branched, pale and slightly thickened toward the apex; asci short-clavate; spores oblong to ellipsoid, straight or slightly curved, 11 to 16 μ long and 5 to 7 μ wide.

Found in the northern portion of the State and almost wholly confined to balsams.

In North America confined for most part to arctic and subarctic regions. Known also in South America, Europe, Africa, and Australia. Some of Arnold's European plants are much larger than ours.

EXPLANATION OF PLATE 41.—See page 204.

3a. *Ramalina pusilla geniculata* (Tayl. & Hook.) Tuck. Syn. N. A. Lich. 1: 26. 1882.

Ramalina geniculata Tayl. & Hook. Lond. Journ. Bot. 3: 655. 1844.

Thallus more commonly compressed, smooth, subdichotomously and frequently much branched, sometimes bearing soredia, the tips of the lobes deflexed.

Occurring with the last, but less common.

North and South American distribution about the same as that of the species. Also known in Europe and Australia.

ALECTORIA Ach. Lich. Univ. 120, 592. *pl. 13. f. 1-4*. 1810.

The thallus is strictly fruticose and cylindrical or compressed-cylindrical, more commonly the latter at the points of branching, and may be erect, spreading, or pendent. Branching is frequent and usually dichotomous or subdichotomous. The pseudocortex consists of a thick layer of stout hyphæ, running for most part parallel in a longitudinal direction, and forming a hollow cylinder, which in some forms is quite rigid, the hyphæ composing a tissue which functions as stereome. The outer hyphæ of the cylinder are usually colored and stronger, the whole structure, however, as is common among lichens, becoming flexible when wet. Within the cortex is the algal layer, consisting of rather scattered clusters of algæ, which form an incomplete hollow cylinder within the cortex. The medullary tissue consists of loosely interwoven hyphæ, traversing the space within the cortex and united here and there with its inner hyphæ. In some species the cortical layer is thinner and the medullary layer traversed by a number of small bundles of longitudinal hyphæ. The color is brown, blackish brown, straw-colored, or sea-green, a given species differing greatly in color and even a given plant at different ages.

The apothecia are rather rare in most of the species, lateral and sessile or immersed, the disk of different color from that of the thallus, the margin usually entire. The hypothecium is pale and consists of two distinct layers. The hymenium is usually pale or slightly colored below and darker above. The paraphyses are usually simple. The spores are simple (the genus in the Tuckermanian sense also including species having compound spores), colorless, or becoming brownish, 2, 3, 4, or 8 in each ascus.

The genus seems to be very closely related to *Usnea*.

A single species, with two subspecies, occurs in the State. On trees and old wood.

Type species *Alectoria jubata* (L.) Ach. loc. cit.

KEY TO THE SPECIES.

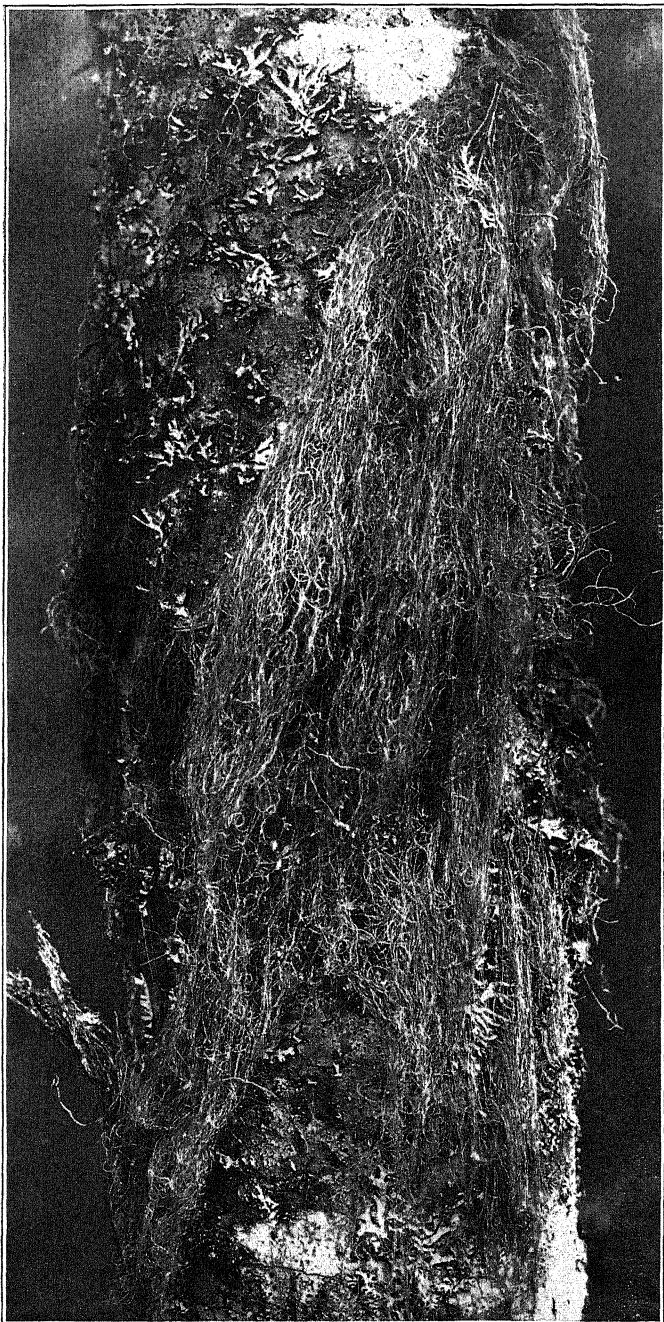
- Thallus rather short, spreading, prostrate, or subpendent, commonly sorediate..... 1a. *A. jubata chalybeiformis*.
- Thallus long and pendent.
- Thallus freely branching dichotomously, brown or sometimes in part or wholly sea-green..... 1. *A. jubata*.
- Thallus much elongated, more freely branched and the branches intertangled, brown or darker throughout.... 1b. *A. jubata implexa*.

1. *Alectoria jubata* (L.) Ach. Lich. Univ. 592. *pl. 13. f. 2*. 1810.

Lichen jubatus L. Sp. Pl. 1155. 1753.

PLATE 42, A.

Thallus tufted, slender, long and pendent, freely branching dichotomously, subcylindrical, brown, blackish brown, or sometimes wholly or in part sea-green; ours



A. *ALECTORIA JUBATA* (L.) Ach.



B. *USNEA LONGISSIMA* Ach.

at least seldom if ever sorediate, 5 to 17.5 cm. long; apothecia chestnut-brown, plane or convex, small, 1 to 2 mm. in diameter; spores colorless (possibly becoming brownish), short-ellipsoid, 6 to 9 μ long and 4 to 5 μ wide.

Ours sterile, and the data regarding apothecia taken principally from Nylander.

Common in the northern portion of the State, the first subspecies being the only form thus far known farther south in Minnesota. However, the above-described form has been found in northeastern Iowa and doubtless occurs in southeastern Minnesota. Ours on trees, but on sandstone in Iowa.

Distributed throughout North America, but usually confined to mountains southward. Usually sterile except in mountains or at the extreme north. Generally distributed throughout all the grand divisions.

EXPLANATION OF PLATE 42.—A, Plant of *Alectoria jubata* on trunk of a balsam fir, showing the pendulous fruticose thallus. B, Plant of *Usnea longissima* hanging from the limb of a tree, containing strands several feet long. A natural size; B, about one-eighth natural size.

1a. *Alectoria jubata chalybeiformis* (L.) Ach. Lich. Univ. 593. 1810.

Lichen chalybeiformis L. Sp. Pl. 1155. 1753.

Thallus shorter, spreading, prostrate, or subpendulous, more rigid than the species, rather remotely and divaricately branched, flexuous, brown or brownish sea-green, commonly more or less sorediate, usually sparingly fibrillose, especially along the smaller branches, the fibrils frequently occurring several in a cluster, shorter than in the type, 15 to 85 mm. long.

Ours is uniformly sterile, and no statement of apothecial characters could be found. Probably worthy of specific rank, but perhaps may best stand as a subspecies in the absence of spore characters, etc.

The most common form in Minnesota and quite generally distributed over the State. On trees and no doubt yet to be found on rocks.

Common throughout the northern United States, Alaska, and British America; fertile in mountains. Also distributed throughout northern Europe and Asia.

1b. *Alectoria jubata implexa* (Hoffm.) Ach. Lich. Univ. 593. 1810.

Usnea implexa Hoffm. Deutsch. Fl. 2: 134. 1795.

Thallus pendent and slender, much branched and intertangled, elongated 10 to 17.5 cm. long; brown throughout; apothecia not seen.

Collected in the Misquah Hills and at Beaver Bay, once in each locality. On trees.

Distributed throughout the Northern States and British America; fertile in mountains. Occurs also in Europe, though Nylander does not seem to recognize the subspecies.

USNEA (Dill.) Adans. Fam. Pl. 2: 7. 1763.

The thallus is fruticose and frequently very long. Besides being the longest of lichen thalli, it shows the greatest specialization of the fruticose type. Branching is common, and the main trunks and the branches are usually cylindrical though rarely angular. A pseudocortex is developed on all sides of the cylindrical thallus. Inside of the quite thick cortex lies the algal layer in the form of a hollow cylinder. The medullary tissue within is dimorphic, the center consisting of a solid cylinder of densely packed hyphæ, extending in a longitudinal direction, and surrounding this a cylinder of loosely interwoven hyphæ, uniting internally with the solid portion of the medullary tissue and externally with the cortex. The colors are sea-green or rarely straw-colored, varying to reddish brown.

The apothecia are orbicular, most frequently terminal or subterminal on the branches, the disk pale in all of ours, usually flat and thin, the thalloid margin bearing fibrils. The hypothecium and the hymenium are both pale. The spores are hyaline, simple, ellipsoid or rounded-ellipsoid, and scarcely differ enough in the various species to have much diagnostic value.

The genus seems closely related to Evernia and yet closer to Alecatoria. Nine species and subspecies have been reported from Minnesota, of which *Usnea barbata* is the only one generally distributed over the State.

On trees, old wood, and rarely on rocks.

The Usneas are difficult to determine in some instances, and some of our species and subspecies are by no means certain.

Type species *Lichen plicatus* L. Sp. Pl. 1154. 1753. (*Usnea barbata plicata* (L.) Fr.) Based on *Coralloides* Dill. Musc. pl. 11. f. 1. 1741, identified in L. Sp. Pl. 1154. 1753.

KEY TO THE SPECIES.

Thallus short, scarcely pendent.

Thallus sea-green or grayish.

Thallus usually erect, strigose-fibrillose..... 1. *U. barbata*.

Thallus longer and inclined to pendent conditions,
fibrillose and sorediate..... 1a. *U. barbata hirta*.

Thallus rusty red, otherwise similar to the last above..... 1b. *U. barbata rubiginosa*.

Thallus long and pendent.

Thallus stout and rigid.

Trunks angulate..... 2. *U. angulata*.

Trunks not angulate, quite fibrillose..... 1c. *U. barbata ceratina*.

Thallus more slender.

Thallus foveolate-lacunose toward the base..... 4. *U. cavernosa*.

Thallus not foveolate-lacunose.

Branches clothed with fibrils.

Fibrils long and numerous; the thallus very
long..... 3. *U. longissima*.

Fibrils shorter and less numerous..... 1d. *U. barbata dasy-poga*.

Fibrils few or absent..... 1e. *U. barbata plicata*.

1. *Usnea barbata* Fr. Sched. Crit. Lich. Exsicc. Suec. 8: 34. 1826.

Thallus fruticose, stout, erect or spreading, rather short, 20 to 60 mm. in length, rigid, branched divaricately, grayish to sea-green in color, more or less strigose, fibrillose, the branches and main trunks cylindrical; apothecia terminal or subterminal, varying considerably as to size, 3 to 10 mm. in diameter, commonly more or less concave, the disk pale flesh-colored or slightly brownish or reddish, the margin clothed more or less with fibrils, these also frequent on the under side; hypothecium pale; hymenium pale throughout; paraphyses simple or rarely branched, with pale and somewhat thickened tips; asci clavate or cylindrico-clavate; spores ellipsoid, 7 to 10 μ long and 5 to 6 μ wide.

Generally distributed in the State. On trees and old wood, and rarely on rocks. Commonly fruited in the southern part of the State, but not known to fruit northward in the State, though quite common.

This species occurs in all parts of North America and is quite cosmopolitan also in its foreign distribution. It is the *Usnea barbata florida* (L.) Fr.^a of most authors.

1a. *Usnea barbata hirta* (L.) Fr. Lich. Eur. 18. 1831.

Lichen hirtus L. Sp. Pl. 1155. 1753.

Thallus somewhat more slender and less rigid than the last, consequently less often erect but more inclined to be pendent, though not long; more or less fibrillose, with small fibrils and thickly sprinkled with soredia, of same color as the last.

^a Lich. Eur. 18. 1831.

Ours at least is uniformly sterile. One plant referred here, no. 716 from Emo, is a peculiar form, having larger fibrils and also unusually large soredia. It seems to be intermediate between this subspecies and the last above.

The most common subspecies, and to be looked for on trees in any part of the State.

Found in all parts of North America and Europe.

1b. *Usnea barbata rubiginea* Michx. Fl. Bor. Amer. 2:332. 1803.

Thallus usually quite similar to that of the last, but sometimes more rigid, with stouter fibrils, differing in the rusty red color.

Our specimens are sterile. Acharius mentions the apothecia in *Lichenographia Universalis*. Nylander has not recognized this subspecies so far as the writer can ascertain, and it may well be doubted whether a subspecies should be founded upon the variation in color.

This form has been collected at Minneapolis, Taylors Falls, and Mankato on sandstone, also at Redwood Falls on granite. Is thus confined to the southern half of the State and for the most part to sandstone.

Strictly a North American subspecies.

1c. *Usnea barbata ceratina* (Ach.) Nyl. Syn. Lich. 1:268. 1858.

Usnea ceratina Ach. Lich. Univ. 619. 1810.

Thallus rather stout and rigid but rather or very long and always pendent, branching freely, quite fibrillose, grayish to sea-green; apothecia absent from ours, said to be of middle size or even large.

Common in the northern part of the State, Henning being the most southern Minnesota station known. On trees.

The subspecies is distributed over all parts of North America, though its distribution in Minnesota would seem to indicate that it might be a northern form. Widely distributed in Europe and also known in Asia and South America.

1d. *Usnea barbata dasypoga* Ach. Lich. Univ. 624. 1810.

Usnea plicata dasypoga Ach. Meth. Lich. 312. 1803.^a

Thallus more slender and lax than in the last, as long or longer and not branching so freely, quite as fibrillose and of same color, in foreign specimens sometimes yellowish.

Nylander says "*similis floridæ, sed thallo elongato pendulo*," his brief description thus implying characters quite different from those ascribed to the subspecies by Acharius in his original description.

Collected only at Henning and at Rose Lake, but apparently common on trees at both localities. Doubtless quite frequent in the northern portion of the State, but easily overlooked on account of its close resemblance to the last above.

Distributed over the northern United States and British America and farther south in mountains. Widely distributed in Europe and occurring in Africa and Brazil.

1e. *Usnea barbata plicata* (L.) Fr. Lich. Eur. 18. 1831.

Lichen plicatus L. Sp. Pl. 1154. 1743.

Thallus pendent and much elongated, slender and lax, subdichotomously branched, paler in color, the fibrils absent or evanescent; apothecia absent in ours, said to be small and infrequent.

The form referred to here seems to be common about Ely, and a specimen was collected on Flag Island in Lake of the Woods. Not known farther south in the State. On trees.

^a*Dasypoga* was in the original misprinted as *dasopoga*.

Distributed over the northern part of the United States and over Alaska and British America, and farther south in the mountains. Also widely distributed in Europe and found in South America.

2. *Usnea angulata* Ach. Syn. Lich. 307. 1814.

Thallus fruticose, rather stout and rigid but much elongated and pendent, the main trunk at least more or less angulate and lacunose, branched rather remotely, at least toward the ends, thickly covered with rather long pointed fibrils, grayish to sea-green in color, 6 to 25 cm. long; apothecia absent from ours, but said to be small with flesh-colored disk bearing a white bloom. "Spores rounded-ellipsoid, 5 to 8 μ long and 4.5 to 5.5 μ wide." Other microscopic data not obtainable.

A single specimen has been collected in the State, viz, by Macmillan on a tamara-rack in a swamp near Minneapolis.

Widely distributed in the United States east of the western Cordilleras, and also frequently reported from South America. Otherwise only known on certain islands of the Southern Hemisphere.

3. *Usnea longissima* Ach. Lich. Univ. 626. 1810.

PLATE 42, B.

Thallus fruticose, varying in length from 10 to 150 cm., or even longer, the point of attachment to the substratum seldom to be found, the plants usually hanging free over the branches of trees, cylindrical or somewhat compressed, roughened, ours quite slender and lax, though other specimens are usually stouter, rather sparingly branched, clothed with usually long fibrils, these commonly horizontal and rather straight, light or darker sea-green; apothecia said to reach middle size, but small and terminal in specimens at hand, 1 to 2.5 mm. in diameter, the disk pale flesh-colored and concave, the margin bearing long fibrils; hypothecium pale; hymenium pale or brownish; paraphyses simple or branched, with pale but somewhat thickened apices; asci clavate to cylindrico-clavate; spores oblong-ellipsoid, 9 to 10 μ long and 4 to 5 μ wide.

Ours uniformly sterile, the above microscopic features of the apothecia taken from Arnold's European Exsiccati, no. 1685a.

Frequent along the north shore of Lake Superior and rarely occurring back from the shore near the northern boundary. On trees.

Distributed throughout northern United States, Alaska, and British America, especially in the mountains. Occurring in all the grand divisions.

EXPLANATION OF PLATE 42.—See p. 207.

4. *Usnea cavernosa* Tuck. in Agassiz, Lake Superior 171. 1850.

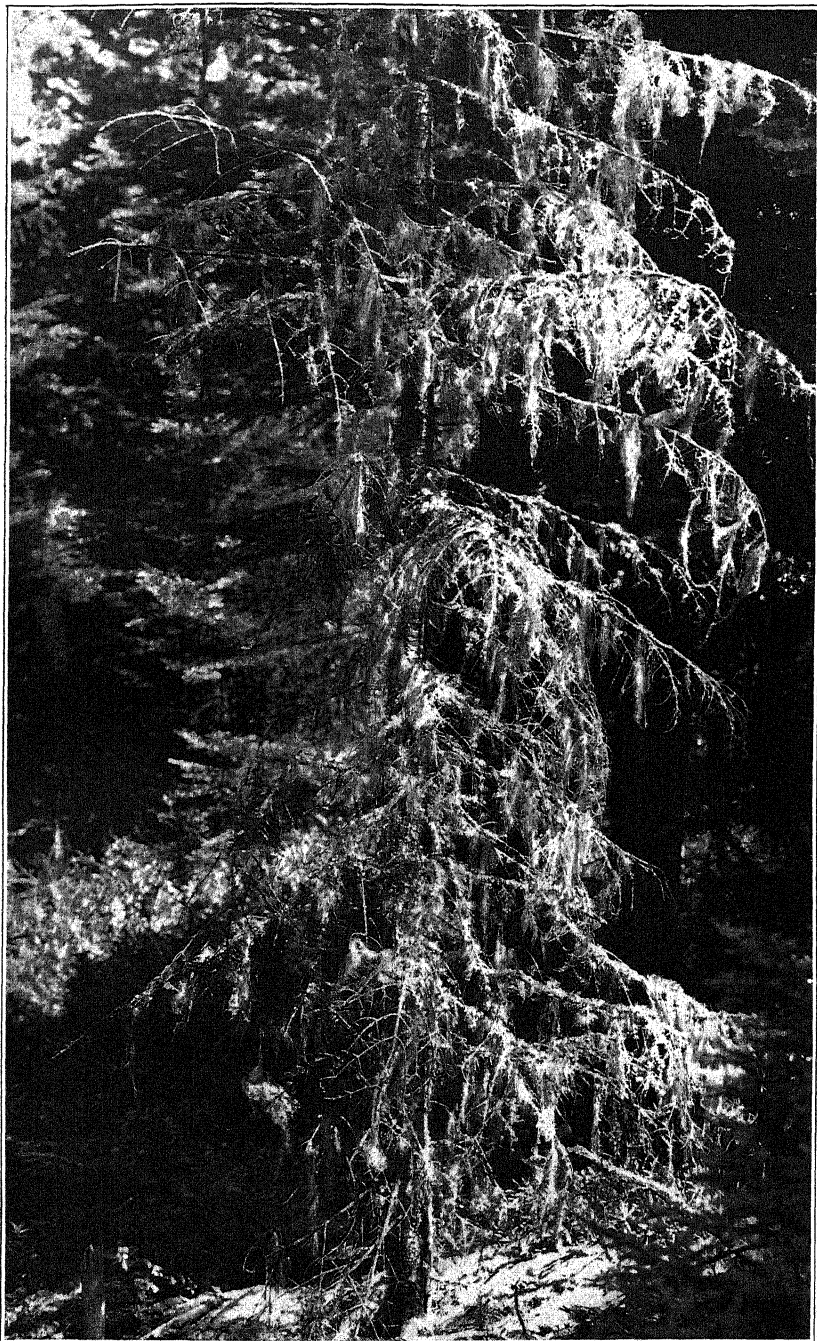
PLATE 43.

Thallus pendent, elongated, 10 to 35 cm. long, the basal enlarged portions often reaching 3 to 5 mm. in diameter, compressed-cylindrical or angulate, foveolate-lacunose toward the large basal portions of the main stems, rather sparingly branched below but much dichotomously branched above, the branches finally very small and much interwoven; scarcely fibrillose or the basal enlarged and somewhat compressed portions of the main trunks occasionally quite fibrillose, especially along the margins; light or darker sea-green; apothecia small to middle-sized, 1 to 6.5 mm. in diameter, seldom terminal; the disk pale flesh-colored and concave; the margin, in ours at least, quite strongly fibrillose with long fibrils; hypothecium pale; hymenium pale throughout; paraphyses somewhat distinct, simple or branched, with pale, thickened apices; asci clavate; spores ellipsoid or short-ellipsoid, 7 to 9 μ long and 4 to 5 μ wide in ours.

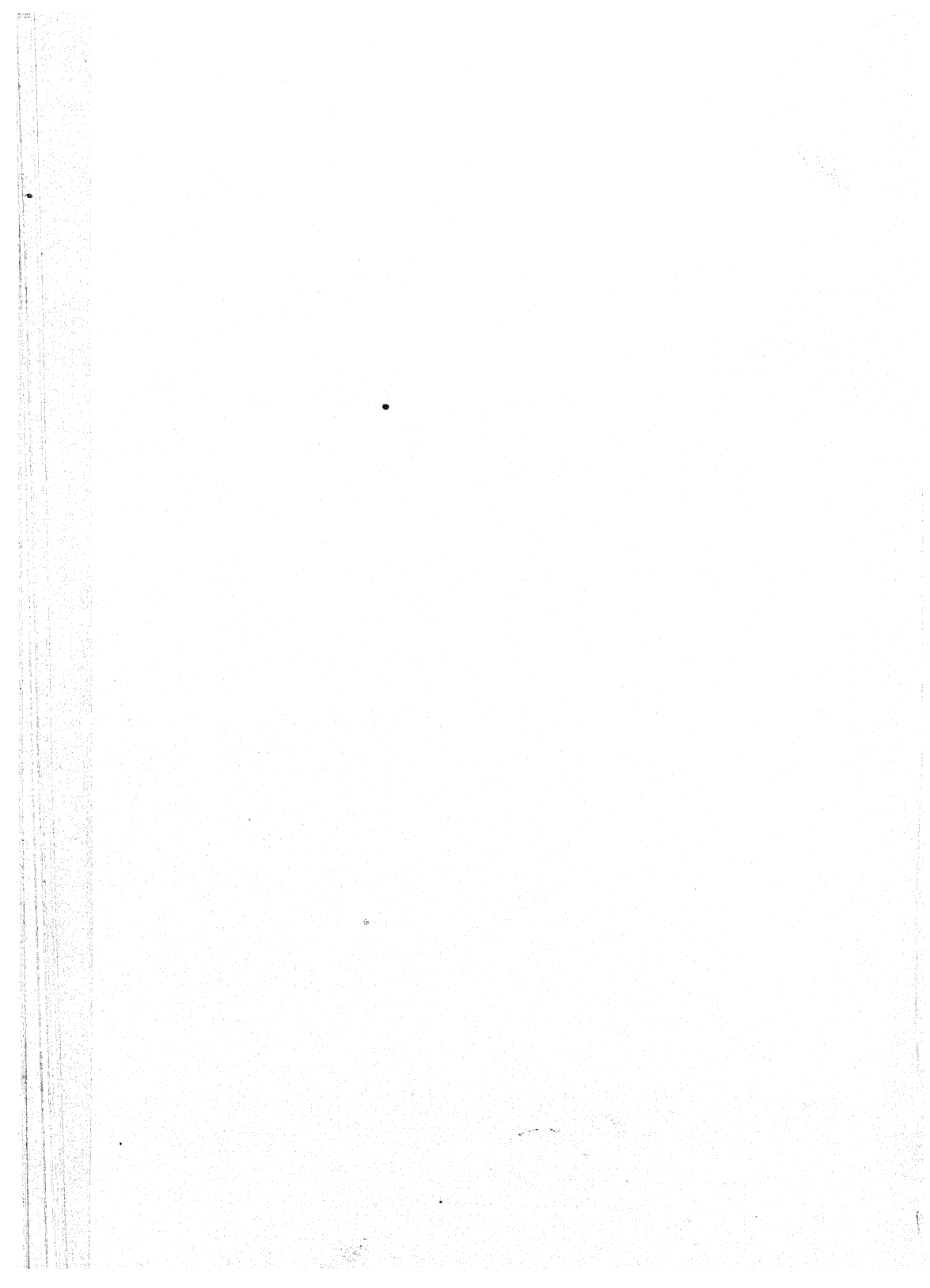
The plant is frequently found in the northeastern one-third of the State. On trees. Tuckerman's statement that the plant strongly resembles *Alectoria ochroleuca sarmentosa* Nyl. is well founded.

Distributed widely in British America, but in the United States confined for most part to mountainous regions. Also known in southern South America and in India.

EXPLANATION OF PLATE 43.—A spruce covered with Usneas and Alectorias, for the most part *Usnea cavernosa*, at Grand Portage. About one-thirteenth natural size.



USNEA CAVERNOSA TUCK.



Family TELOSCHISTACEAE.

This family consists of the two genera, *Placodium* and *Teloschistes*, though some lichenists have made more genera by further subdivision. The peculiarities of the family are the yellow or orange color, due to a deposit of chrysophanic acid commonly found in both thallus and apothecia, and the typically polar 2-celled spores, found constantly or sometimes in nearly all of the species of the two genera.

Of the two genera, *Placodium* with its commonly crustose thallus is plainly the lower, and the spore resemblance in the two would seem to indicate that members of the genus *Teloschistes* were derived phylogenetically from some species of *Placodium*. Also the algal symbiont *Gyrostococcus* is common to both genera.

Squamulose, foliose, and fruticose thalli occur in the family, and the apothecia are either adnate or sessile. The spores may rarely be nonpolar or even simple.

The relationship between the family and the Parmeliaceae was stated in the description of that family and need not be given here. In form and anatomy of the thallus, and in spores and apothecial characters, there is also a less close relationship between the present family and the Physciaceae, the nearest approach of the two families being in the genera *Teloschistes* and *Physcia*, *Placodium* and *Rinodina* being somewhat less closely related as to thallus structure, but equally close as regards the spores.

PLACODIUM (Hill) Web. in Wig. Prim. Fl. Hols. 90. 1780.

The thallus varies from subfoliose to strictly crustose forms, the latter being much more common. As in *Lecanora*, the thallus is closely adnate even in the best developed or subfoliose forms. In these the upper cortex is fairly well developed and commonly shows more or less of cellular structure, while the lower cortex is much thinner and more commonly composed of closely interwoven hyphae. Even in the more crustose species an upper cellular cortex is often more or less developed, and on the whole these crustose thalli are better developed than the similar ones of the *Lecanoras*. Algal and medullary layers are also frequently demonstrable in sections, especially in the more foliose forms. Rhizoids or rhizoidal hyphae are present as attaching organs, but are by no means common and are not often noticed in sections. The algal symbiont is *Gyrostococcus*. The common colors of the thallus are yellow and orange. Fruticose forms are admitted to the genus by some lichenists.

The apothecia are commonly rather small and sessile or adnate. The exciple is commonly thalloid, though a proper exciple is frequently more or less distinctly developed within this. Also the thalloid exciple may disappear, leaving the structure strictly biatoroid. Orange, yellow, and brown are common colors of the disk. The hymenium, hypothecium, and asci are much as in *Lecanora*. The paraphyses are also similar, but scarcely so slender. The spores are hyaline and usually of the polar 2-celled type, but in some of the species they are simply 2-celled and partly simple.

The more crustose and less lobed forms are sometimes separated as the genus *Calopisma*, but the transition is a gradual one, and it has seemed best not to divide the species. The transition in spore forms is also gradual, polar and nonpolar or 2-celled and simple spores quite commonly occurring in the same species and even in the same apothecium. As to spore characters, the present genus is plainly related to *Teloschistes*. As to thallus structure, the relation is as plainly with *Lecanora*, the structure being as a whole rather higher in the present genus.

Fifteen species and subspecies occur in the State. On trees, rocks, and old wood. Type species *Placodium candelarium* (L.) Web. loc. cit.

KEY TO THE SPECIES.

Section I. Thallus more or less lobed at the circumference.

- | | | |
|--|--|--------------|
| Thallus large, 25 to 70 mm. in diameter..... | 1. <i>P. elegans</i> . | |
| Thallus smaller. | | |
| Thallus only 8 to 45 mm. in diameter..... | 2. <i>P. murorum</i> . | |
| Thallus still smaller..... | 2a. <i>P. murorum</i>
<i>atum</i> . | <i>mini-</i> |

Section II. Thallus not lobed at the circumference.

On trees or on dead wood.

On dead wood.

- | | |
|---|---|
| Thallus dirty yellow or orange, of adnate squamules, often forming an areolate crust..... | 4. <i>P. microphyllum</i> . |
| Thallus ashy or whitish. | |
| Thallus persistent and becoming thick and verrucose..... | 9. <i>P. ferrugineum</i> . |
| Thallus thinner and tending to disappear. | |
| Disk yellowish orange; exciple disappearing..... | 8. <i>P. pyraceum</i> . |
| Disk olivaceous and darker; exciple disappearing..... | 9a. <i>P. ferrugineum polli-</i>
<i>ni</i> . |

On trees.

- | | |
|---|---------------------------------|
| Thallus chinky, verrucose or areolate, grayish yellow or yellowish gray (also on rocks and old wood)..... | 6. <i>P. aurantiacum</i> . |
| Thallus thinner and smoother, often chinky, ash-whitish or lead-gray. | |
| Exciple entire..... | 7. <i>P. cerinum</i> . |
| Exciple becoming subcrenulate or radiately striate; disk pruinose..... | 7a. <i>P. cerinum ulmorum</i> . |

On rocks.

Thallus thick and often verrucose.

- Thallus grayish yellow or yellowish gray; disk orange to saffron-colored..... 6. *P. aurantiacum*.
Thallus sea-green to iron-gray; disk yellowish rust-colored to blackish..... 7b. *P. cerinum sideritis*.

Thallus thinner, granulose, chinky, or areolate.

- Thallus chinky-areolate or scattered-scaly, the scales often lobed; usually dark orange..... 3. *P. cinnabarrinum*.

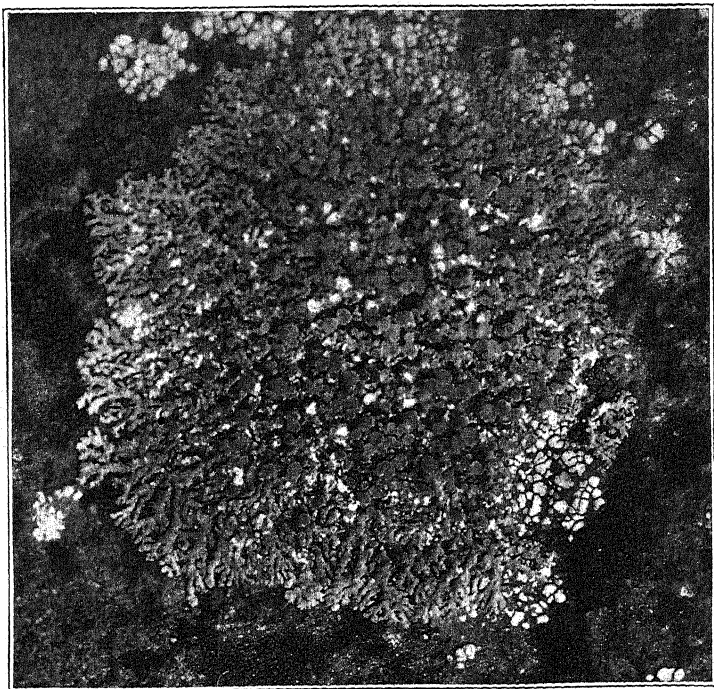
Thallus granulose to areolate.

- Granules minute, lemon-colored, sometimes
compacted into a subareolate crust..... 5. *P. citrinum*.

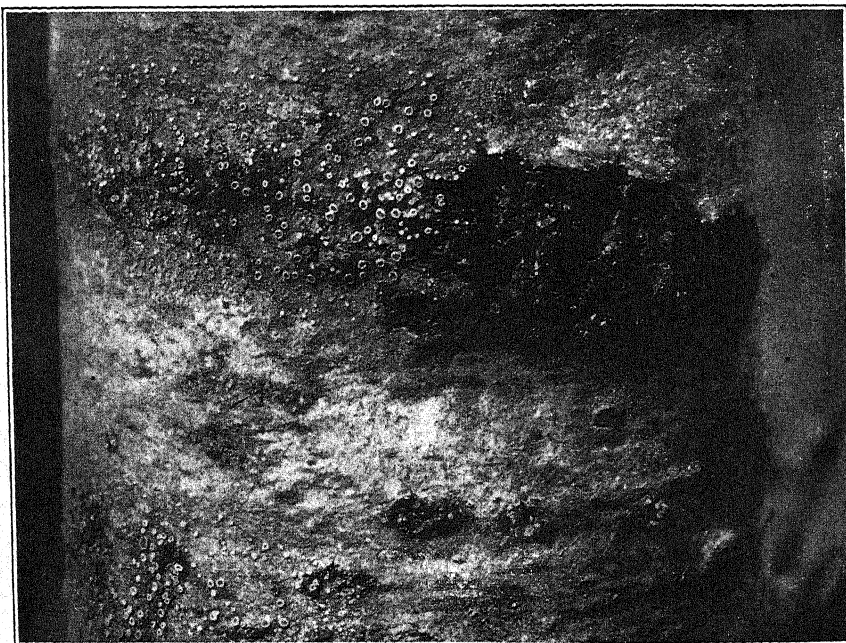
- Granules larger and often crenate-lobed, bright greenish yellow (also on old wood).

- Thallus persistent, the granules often compacted into an areolate crust; exciple granulate, crenate..... 10. *P. vitellinum*.

- Thallus of scattered granules, often disappearing; exciple entire.....10a. *P. vitellinum* *aurellum*.



A. PLACODIUM ELEGANS (LINK) ACH.



B. PLACODIUM CERINUM (HOFFM.) HEPP.

1. *Placodium elegans* (Link.) Ach. Lich. Suec. 102, 255. 1798. PLATE 44, A.

Lichen elegans Link. Beitr. Naturgesch. 1: 37. 1794.

Thallus subfoliose, suborbicular, of medium size, 25 to 70 mm. in diameter, plainly lobed and stellate-radious in the best developed conditions, but closely adnate, the lobes free and becoming long, branched, wavy, convex above, sometimes subimbricate and often more or less lacunose; commonly orange above but varying toward yellowish or reddish, white below or darkening; upper cortex present and of moderate thickness, but not always distinctly cellular, the lower cortex much thinner; apothecia small or middle-sized, 0.5 to 2 mm. in diameter, sessile, the disk flat or concave, commonly orange-colored, the exciple entire or crenulate and of the same color as the thallus, not disappearing in ours at least; hypothecium commonly pale; hymenium pale below and yellowish or brownish above; paraphyses simple or branched, commonly enlarged and darker toward the apex; asci variously cylindric-clavate to broadly clavate; spores ovoid-ellipsoid, polar 2-celled, 9 to 18 μ long and 5 to 8.5 μ wide.

Generally distributed over the State. On rocks.

Throughout North America, but toward the south mostly confined to mountains. Known in all of the grand divisions.

EXPLANATION OF PLATE 44.—A, Plant of *Placodium elegans* on rocks, showing the closely adnate and marginally lobed thallus and the apothecia. B, Plant of *Placodium cerinum* on poplar, showing the small apothecia. A enlarged $1\frac{1}{2}$ diameters; B, 2 diameters.

2. *Placodium murorum* (Hoffm.) Ach. Lich. Suec. 101, 255. 1898.

Lichen murorum Hoffm. Enum. Lich. Icon. 63. pl. 9. f. 2. 1784.

Thallus when well developed orbicular, smaller than in the last, 8 to 45 mm. in diameter, more closely adnate than that of the last and to be regarded as crustose, though there is a poorly developed lower cortex over portions of the ventral surface, the upper cortex as in the last, the central portions commonly more or less verrucose, the margin passing into rather short but somewhat branched lobes, or the marginal lobing absent and the whole thallus composed of discrete verrucæ or squamules, usually bright yellow; apothecia small, 0.4 to 1 mm. in diameter, sessile, the disk flat or concave and orange red, the thalloid exciple thicker than in the last and more commonly crenulate, said to inclose a thin proper exciple; hypothecium commonly pale, hymenium pale below, yellowish above; paraphyses simple or branched, commonly enlarged and yellowish or brownish toward the apex; asci clavate; spores polar 2-celled, ovoid-ellipsoid, 10 to 15 μ long and 5 to 7 μ wide.

Collected at Thief River Falls, at Rainy Lake City, and in the Misquah Hills in the northern portion of the State; also once as far south as Granite Falls. On rocks other than calcareous.

In the northern United States and northward, and also as far south as southern California. Known also in South America, Europe, and Africa.

2a. *Placodium murorum miniatum* (Hoffm.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 136. 1861.

Lichen miniat Hoffm. Enum. Lich. Icon. 62. 1784.

Thallus orange or reddish, smaller, 5 to 20 mm. in diameter; ours sterile.

Collected at Grand Portage. On rocks.

Elsewhere in North America in California. Known also in South America and Europe.

3. *Placodium cinnabarrinum* (Ach.) Anzi, Cat. Lich. Sondr. 43. 1860.

Lecanora cinnabarrina Ach. Lich. Univ. 402. 1810.

Thallus strictly crustose and closely adnate, more or less chinky or areolate, or the areoles scattered and forming scales, these commonly more or less crenately lobed, or the scales still retained in less scattered conditions and becoming somewhat imbricate; suborbicular and rather small, 5 to 30 mm. in diameter, or perhaps more often

hypothecium pale; hymenium pale below and yellowish above; paraphyses simple or branched, frequently enlarged and slightly colored toward the apex; asci clavate; spores polar 2-celled, ellipsoid or ovoid-ellipsoid, 10 to 16 μ long and 5 to 9 μ wide, the number of nonpolar spores larger than in most of the species.

The species seems clear enough as it occurs on old wood, but transitional forms of the last certainly occur on trees.

Generally distributed over the State. On old wood.

Found throughout the northern United States and northward. Also in southern California. Known in all of the grand divisions except Africa.

Placidium cerinum pyracea of the preliminary reports.

9. *Placidium ferrugineum* (Huds.) Hepp, Spor. Flecht. Eur. pl. 45. f. 400. 1857.

Lichen ferrugineus Huds. Fl. Angl. ed. 2. 526. 1778.

Thallus crustose and commonly thin, rather smooth and chinky or becoming rugose and verrucose, ashy or whitish, usually more or less irregular and variously disposed upon the substratum, with a thin layer above the algal cells, but scarcely to be regarded as corticate, the whole thallus sometimes becoming scattered and tending to disappear; apothecia small to almost middle-sized, 0.3 to 1.3 mm. in diameter, the thalloid exciple evanescent and the structure early becoming biatoroid, sessile, the disk flat, rust-colored or blackening, frequently subpruinose; hypothecium brown or brownish; hymenium pale below and brownish above; paraphyses simple or branched, commonly enlarged and brownish toward the apex; spores ellipsoid, polar 2-celled, 11 to 20 μ long and 6 to 10 μ wide.

Collected at such remotely separate localities as Mankato, Bemidji, Red Lake, and Rainy Lake City. On dead coniferous wood. Easily passed over for a *Biatora* and no doubt generally diffused throughout the State.

Generally distributed over North America. Found also in Europe and Africa.

9a. *Placidium ferrugineum pollinii* (Mass.) Tuck. Syn. N. A. Lich. 1: 177. 1882.

Blastenia pollinii Mass. Flora 35: 575. 1852.

Thallus thinner, whitish, and tending to disappear; apothecia biatoroid, becoming more or less convex, the proper exciple tending to disappear, the disk olivaceous and blackening.

Distribution in the State quite as that of the species as is also the habitat.

Elsewhere in North America in New England, Maryland, Illinois, Iowa, and Nebraska. Known also in Europe.

10. *Placidium vitellinum* (Hoffm.) Hepp, Spor. Flecht. Eur. pl. 44. f. 391. 1857.

Patellaria vitellina Hoffm. Descr. Pl. Crypt. 2: 5. pl. 26. f. 2. 1794.

Thallus crustose-granulate, composed of small rounded or finally squamulose and crenate-lobed granules, which may be scattered or grouped into areole-like clusters, bright greenish-yellow, forming a more or less broken or rarely continuous layer, usually irregular and more or less spread over the substratum, with some suggestion of an upper cellular cortex at least over portions of some thalli; apothecia rather small, 0.3 to 1.3 mm. in diameter, sessile, the disk commonly flat, tawny-yellow, becoming olivaceous, the exciple thalloid and granulate-crenate; hypothecium pale; hymenium pale below and yellowish above; paraphyses simple or branched, commonly enlarged and yellowish toward the apex; spores commonly 12 to 32 in each ascus (rarely only 8), ellipsoid, 2-celled and simple, 8 to 16 μ long and 4 to 7 μ wide.

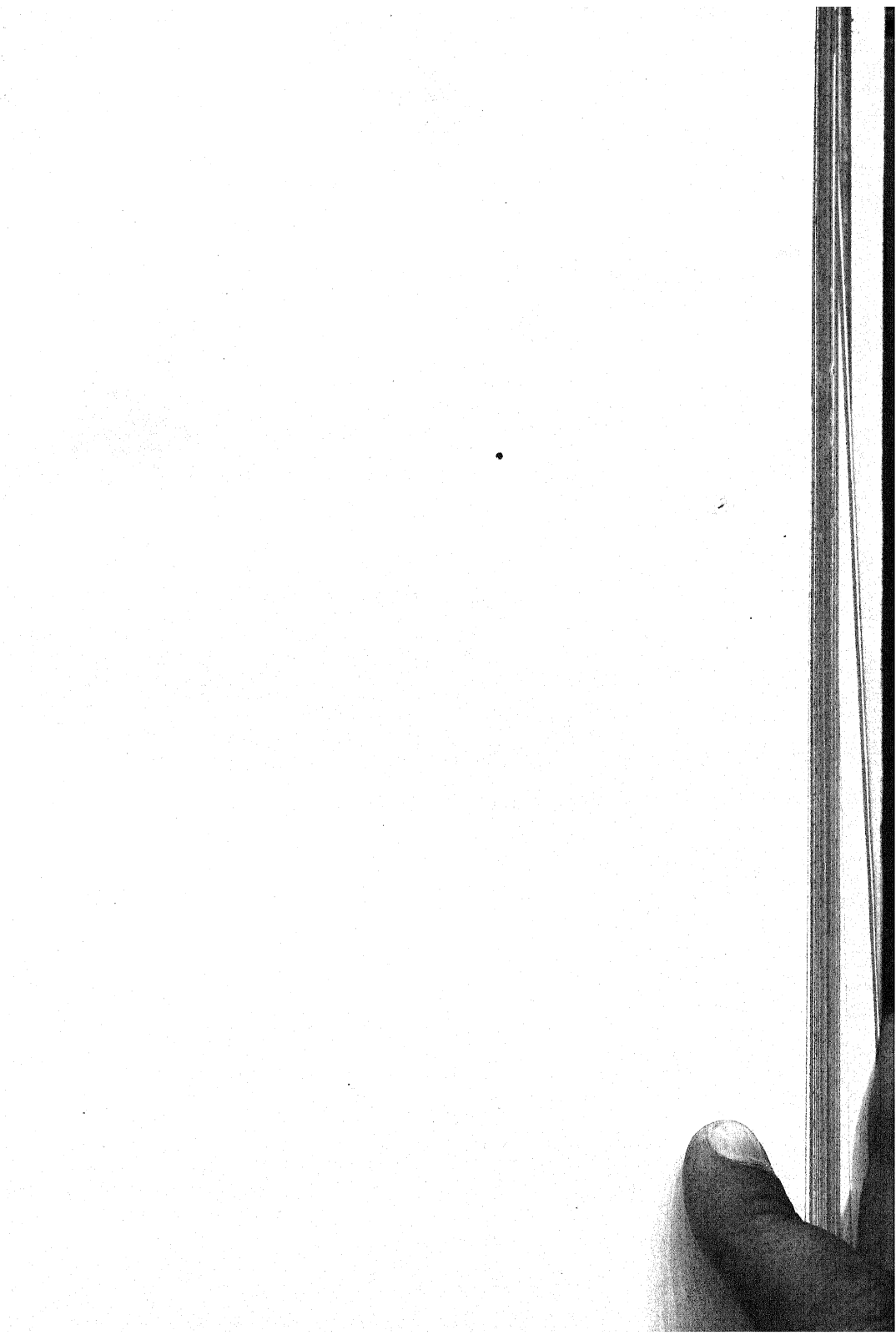
Generally distributed over the State. On rocks and old wood.

Found throughout North America. Known in all of the grand divisions.

10a. *Placidium vitellinum aurellum* (Hoffm.) Tuck. Syn. N. A. Lich. 1: 180. 1882.

Patellaria vitellina aurella Hoffm. Deutsch. Fl. 2: 197. 1795.

Thallus scattered and disappearing; apothecia smaller with entire exciple; spores rather more commonly simple.



Margins of the lobes scarcely raised.

- Thallus commonly yellow or orange; spores
eight in each ascus..... 2. *T. polycarpus*.
Thallus greenish yellow or rarely yellow;
spores many in each ascus..... 4. *T. concolor*.

1. *Teloschistes chrysophthalmus* (L.) Th. Fr. Gen. Het. Eur. 51. 1861.

PLATE 45.

Lichen chrysophthalmus L. Mant. Pl. 2: 311. 1771.

Thallus tufted, subfruticose, erect, spreading, or showing a pendent tendency, quite rigid, fibrillose, the long lobes compressed and freely branching dichotomously, the fibrils few or more numerous toward the apices of the lobes, showing a pseudo-cortex; yellow to sea-green toward the top and paler toward the bottom and on the lower side; 4 to 15 mm. long, though plants from outside the State are frequently longer; apothecia small or medium, 1 to 5 mm. in diameter, terminal or subterminal, the margin more or less ciliate, or devoid of cilia in ours; the disk orange, concave or flat; hypothecium pale; hymenium pale below and pale or pale yellowish above; paraphyses conspicuously jointed, branched toward the apex, the apices of the branches pale or yellowish and often somewhat thickened; asci cylindrico-clavate or ovate-cylindrical; spores ellipsoid, polar 2-celled or occasionally some of them not polar, 10 to 16 μ long and 5 to 8 μ wide.

Infrequent, but known to exist in all parts of the State except the northeastern portion. On trees or old wood.

Occurring in some form in all parts of North America. Also distributed throughout all the grand divisions.

2. *Teloschistes polycarpus* (Hoffm.) Tuck. Syn. N. A. Lich. 1: 50. 1882.

PLATE 46, A.

Lobaria polycarpa Hoffm. Deutsch. Fl. 2: 159. 1795.

Thallus foliose, 6 to 20 mm. in diameter, prostrate, the margins scarcely raised, circular or irregular, the lobes small, narrow, freely divided or occasionally much reduced, imbricated or often scattered, the lower side more or less furnished with pale rhizoids and marginal pale or yellow fibrils, frequently almost wholly concealed by the commonly numerous apothecia, yellow or orange above or varying toward brownish or grayish, pale beneath; apothecia orange or at least darker than the thallus and having a paler entire or crenulate margin, rather small and commonly very numerous, concave or flat, commonly subpedicellate, rarely more or less fibrillose below, 1 to 4 or rarely 5 mm. in diameter; hypothecium pale; hymenium pale below and pale or yellowish above; paraphyses conspicuously jointed and usually branched toward the apex, the apices of the branches pale or yellowish and enlarged; asci ovate-clavate or cylindrico-clavate; spores ellipsoid, polar 2-celled or occasionally partly nonpolar, 12 to 18 μ long and 5 to 8 μ wide.

Our most common species, and found in all parts of the State. On trees, old wood, and very rarely on rocks.

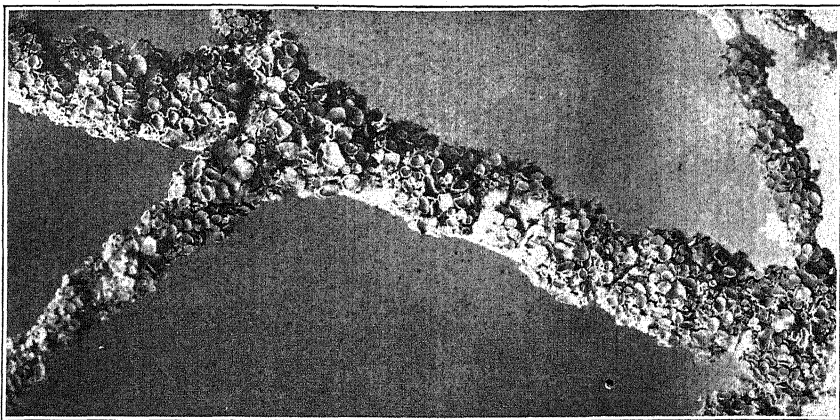
Occurs in all parts of North America. Also distributed throughout the grand divisions.

EXPLANATION OF PLATE 46.—A, Plant of *Teloschistes polycarpus* on a dead branch, showing the numerous apothecia characteristic of the species. B, Plant of *Rinodina sophodes* on a tree trunk, showing the crustose thallus and the apothecia. A and B enlarged 1½ diameters.

3. *Teloschistes lychnus* (Ach.) Tuck. Syn. N. A. Lich. 1: 50. 1882.

Parmelia candelabra lychna Ach. Meth. Lich. 187. 1803.

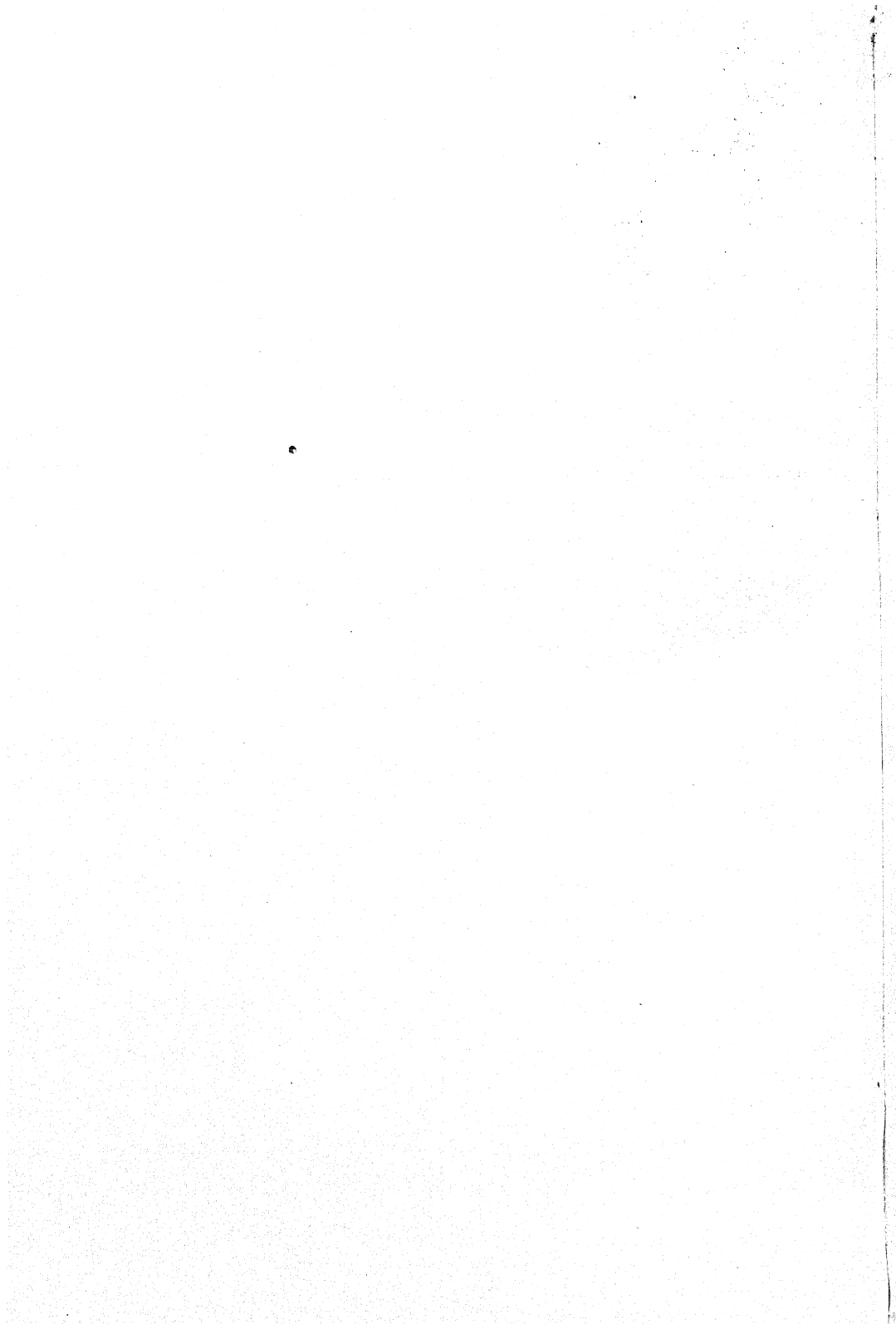
Thallus foliose, rather larger than in the last, 12 to 35 mm. in diameter, ascending or subprostrate with ascendant margins, compact and the lobes more or less imbricate, these in ours larger, wider, and rather less divided than in the last, the margins isidioid-granulate, the lower side more or less furnished with pale rhizoids and



A. *TELOSCHISTES POLYCARPUS* (HOFFM.) TUCK.



B. *RINODINA SOPHODES* (ACH.) KOERB.



marginal pale or yellow fibrils; yellow or orange above and pale below; apothecia rather rare, of the same size as in the last and of the same color or commonly brighter and occasionally even orange-red, the margin entire, crenulate or isidioid-granulate, commonly subpedicellate, and sometimes fibrillose below; hypothecium pale or slightly darkened; hymenium pale or yellowish-tinged, or yellowish above only; paraphyses conspicuously jointed and commonly branched toward the apex, the tips pale or yellowish and usually enlarged; asci ovate-cylindrical or cylindrico-clavate; spores oblong to ellipsoid, the mature ones, as in the two species above, being at least very largely polar 2-celled, 12 to 16 μ long and 5.5 to 7.5 μ wide.

The plant as it occurs in Minnesota is a large form of the species, our description varying somewhat from that of Tuckerman, especially as to the size of the plant and form of the lobes. Ours is nearer than usual to *Teloschistes parietinus*, but it never need be confused either with this or the last species above.

As widely distributed in the State as the last, but rather rare. On trees and rarely on rocks.

Widely distributed in North America as also in northern Euro-Asia. Known also in South America.

4. *Teloschistes concolor* (Dicks.) Tuck. Syn. N. A. Lich. 1: 51. 1882.

Lichen concolor Dicks. Pl. Crypt. Brit. 3: 18. pl. 9. f. 8. 1793.

Thallus foliose, smaller than in the above foliose species, suborbicular or the lobes scattered, when not scattered 4 to 25 mm. in diameter, prostrate or the margins sometimes slightly ascending, compact with lobes more or less imbricate or even passing into a continuous roughened crust toward the center, or the lobes more or less scattered and usually very narrow and irregularly much divided at least toward the circumference, the margins frequently finely granulate, the lower side bearing numerous pale rhizoids and pale marginal fibrils; greenish yellow or rarely yellow above and pale beneath; apothecia of same color as the thallus or more commonly a brighter yellow or rarely brownish, the margin entire or crenulate, sessile, and sometimes fibrillose below, 0.5 to 1.5 mm. in diameter; hypothecium pale or slightly darkened; hymenium pale or yellowish above; paraphyses plainly jointed, simple or rarely branched at the tips, these pale and enlarged; asci clavate, large; spores simple or 2-celled (not polar), many in each ascus, oblong, 5 to 11 μ long and 3 to 5 μ wide.

Distributed over all of the State except the northeastern region covered by the fourth report of the preliminary survey. On trees and old wood.

The plant is widely distributed in North America and is also known in Europe, Asia, and South America.

4a. *Teloschistes concolor effusus* Tuck. Syn. N. A. Lich. 1: 52. 1882.

Thallus lobes reduced to squamules, these granulose, at least at the margins, and passing sometimes into a powdery crust; in ours the squamules frequently scattered.

A form has also been placed here which has the apothecial characters of the present subspecies, but has the thallus reduced to scattered granules.

The subspecies has been reported from several localities in the northwestern portion of the State and from Mankato, well to the south. However, some of our specimens are hardly the subspecies. On trees.

Tuckerman gives the subspecies the same North American distribution as the species. Apparently not noted elsewhere.

Family PHYSCIACEAE.

If we take into account the three elements—thallus structure, the development of the apothecia, and the spore characters, we have plainly enough in the Physciaceae the highest family of the Discocarpaceae. And this becomes more apparent with our disposition of *Urceolaria* in the present family.

It is by no means plain that the present family is highest as regards thallus structure or development of the apothecia, but it is when we consider these elements in connection with the spore characters that the position of the family becomes apparent. We have the muriform spore in the Gyrophoraceae, the Lecideaceae, and the Graphidaceae as well as here, but always in connection with lower types of structure of thallus or apothecia, or both.

The relationships of the family with the Parmeliaceae and the Teloschistaceae have been given in the descriptions of those families, and it need only be added here that in admitting *Urceolaria* to the present family we have established a somewhat close relationship with the Gyalectaceae, through *Urceolaria* and *Conotrema*.

The first two genera of the family are well represented in our flora, but our members of the family as a whole are not very numerous. The thallus structure shows about the same amount of variation as is found in the last family, and the relationship of the apothecia to the thallus is about the same as in the Parmeliaceae. But the spores are always brown and vary from 2-celled to muriform conditions.

RINODINA Ach.; S. F. Gray, Nat. Arr. Brit. Pl. 1: 448. 1821.

The thallus is crustose, though in a few species herein admitted to the genus there is more or less of lobing at the circumference. The structure is closely adnate, usually areolate, and is attached to the substratum by commonly dark hyphal rhizoids. In the lobed forms, there is more or less of an upper pseudocortex of hyphae, but in the lower more strictly crustose species, the cortex is absent, or rather represented by a bending and branching of the hyphae near the upper surface, to form the poorly developed protective layer so common in crustose thalli. The algal symbionts are commonly *Cystococcus*, though they vary considerably in size in the different species, and in some species having larger and more irregular algae, *Pleurococcus* may replace the usual *Cystococcus*. The common colors of the thalli are sea-green, ashy, straw-color, and yellowish.

The apothecia are commonly small or minute, and may be immersed, adnate, or sessile. Indeed, all of the above dispositions of apothecia may occur in a single species. The exciple is thalloid, but in a majority of the species this structure may disappear entirely. The disk is commonly flat and its color usually black or brownish black. The hypothecium is commonly pale, though sometimes brownish. The paraphyses are simple or rather rarely branched. The spores are brown and 2-celled.

The present genus is doubtless to be regarded as intermediate between *Physcia* and *Buellia*, lower than the former and on the whole higher than the latter. The thalli of the best developed *Rinodinas* seem quite as high as those of the lowest *Physcias*, while some of the lower members of the present genus show thalli scarcely better developed than those of some of the *Buellias*. The thalli and the apothecia of the *Rinodinas* also resemble those of *Lecanoras* and *Placodiums*, but the spores indicate a much closer relationship with the two genera named above. Finally, the tendency of the thalloid exciple to disappear looks toward *Buellia*. Possibly our *Rinodina oreina* should be excluded from the genus, but the thallus is after all essentially crustose.

Ten forms occur in the State. On trees and rocks.

Type species *Rinodina atra* (Huds.) S. F. Gray, loc. cit. But this is *Lecanora atra*, and the generic name *Rinodina* will doubtless have to be abandoned eventually.

KEY TO THE SPECIES.

Confined to rocks.

Thallus blackish, of flat or concave areoles..... 6. *R. nigra*.

Thallus lighter-colored.

Thallus granulose, becoming chinky, scurfy or sub-areolate, whitish, sea-green or brownish..... 4. *R. bischoffii*.

Thallus never granulose, but more or less chinky-areolate.

Thallus with plainly lobed and often black-fringed margin; greenish straw-colored or yellowish..... 1. *R. oreina*.

Thallus chinky or scaly-areolate, not lobed; sea-green to olivaceous..... 5. *R. lecanorina*.

Not confined to rocks.

On trees or dead wood.

Thallus and exciple thin and disappearing..... 3d. *R. sophodes exigua*.

Thallus and exciple thicker and more persistent.

Spores 20 to 35 μ long..... 2. *R. ascociscana*.

Spores 14 to 22 μ long..... 3b. *R. sophodes phraspis*.

Habitat various.

Thallus coarse, verrucose and sometimes lobulate, whitish..... 3c. *R. sophodes confragosa*.

Thallus finer, granulose or granulose-areolate.

Thallus of minute granules, sometimes forming a subareolate crust; ashy to olive-brown..... 3. *R. sophodes*.

Thallus granulose-areolate, or scattered sub-squamulose; ashy to sea-green..... 3a. *R. sophodes atrocinerea*.

1. *Rinodina oreina* (Ach.) Mass. Ric. Lich. 16. f. 24. 1852.

Lecanora straminea oreina Ach. Lich. Univ. 433. 1810.

Thallus verrucose-areolate, except the margin which passes into distinct and more or less lobed squamules or somewhat elongated, branched, and usually densely crowded lobes, the areoles or verrucae about 0.5 to 1 mm. across, greenish straw-colored or yellowish, the marginal lobes or squamules, at least, showing a thin upper pseudo-cortex of mostly vertical hyphae and the algal and medullary layers somewhat differentiated, suborbicular with the marginal lobes or squamules well represented, or becoming irregular and more widely spread over the substratum with the lobation tending to disappear, the more regular forms commonly 12 to 55 mm. across, the margin commonly more or less black-edged; apothecia small or minute, 0.2 to 0.75 mm. in diameter, immersed or becoming adnate, or even sessile, the disk black and commonly flat, the thalloid exciple obtuse and entire, rarely disappearing, the apothecia then somewhat lecidoid; hypothecium pale; hymenium commonly pale beneath and brown or brownish above; paraphyses simple or branched, commonly thickened and brownish toward the apex; asci clavate; spores short-ellipsoid, 9 to 12 μ long and 4.5 to 7.5 μ wide.

Generally distributed over the State. On rocks other than calcareous.

Throughout North America, except the most southern States and southward. Found also in Europe.

2. *Rinodina ascociscana* Tuck. Gen. Lich. 124. 1872.

Psoroma ascociscana Tuck. Amer. Journ. Sci. 25: 424. 1858.

Thallus a suborbicular, chinky crust, which becomes more or less concentrically wrinkled and passes into scaly-areolate conditions, scarcely corticate, sea-green and passing into a pale cinnamon-brown; apothecia small to middle-sized, 0.6 to 1.5 mm. or more in diameter, sessile, the disk flat or slightly convex, from pale brown to black, the thalloid exciple persistent, entire or crenate; hypothecium pale; hymenium of same color below and brownish above; paraphyses simple or rarely branched, commonly enlarged and brownish toward the apex; asci clavate; spores 20 to 35 μ long and 10 to 16 μ wide.

Our plant is scarcely so well marked as Tuckerman's and may yet prove to be an unusually well developed form of the next species below.

Collected at Gunflint and at Tofte. On trees.

A North American plant found elsewhere in New England, in Illinois, and in arctic America.

3. *Rinodina sophodes* (Ach.) Koerb. Syst. Lich. 122. 1855.

PLATE 46, B.

Lichen sophodes Ach. Lich. Suec. 67. 1798.

Thallus composed of minute granules, these running together to form a thin, continuous, or more or less scattered, granulate and roughened or subareolate crust, ashy and passing into olivaceous-brown, irregularly and often widely spread over the substratum; apothecia small or minute, 0.3 to 0.8 mm. in diameter, adnate, the disk flat or convex and brown to blackish, the thalloid margin entire or subentire and inclosing a thin and more persistent proper exciple, the thalloid one frequently tending to disappear; hypothecium pale to brownish; hymenium pale below and commonly brownish above; paraphyses simple or rarely branched toward the commonly enlarged and brownish apex; asci clavate; spores oblong-ellipsoid, 14 to 22 μ long and 6 to 12 μ wide.

Found throughout the State. On trees, old wood, and rocks.

Distributed throughout North America. Known also in all of the grand divisions.

EXPLANATION OF PLATE 46.—See p. 218.

3a. *Rinodina sophodes atrocineræa* (Dicks.) Tuck. Syn. N. A. Lich. 1: 207. 1882.

Lichen atrocineræus Dicks. Pl. Crypt. Brit. 3. 14. pl. 14. f. 9. 1793.

Thallus granulose areolate or subsquamose and the areoles or squamules somewhat scattered; apothecia scarcely ever minute, the thalloid exciple often disappearing; spores of the usual size.

Collected at Bemidji. On cedars in swamps. Said to be a rock form, but ours seems to belong here.

Definitely reported, as far as known, only from California and Ontario, but doubtless widely distributed in North America. Known also in Europe.

3b. *Rinodina sophodes tephraspis* Tuck. Syn. N. A. Lich. 1: 208. 1882.

Rinodina tephraspis Tuck. Amer. Journ. Sci. 25: 425. 1858.

Thallus thickened and roughened, composed of crenulate, or more often verrucose-irregular and crowded areoles, brownish-ashy; apothecia finally middle-sized and prominent, 0.6 to 2 mm. in diameter, becoming convex, hemispherical, and variously irregular, the thalloid exciple said to be persistent, but disappearing in ours.

Collected at Pipestone, at Warroad, on Flag Island in Lake of the Woods, and at Tower, thus apparently widely distributed in the State. On rocks other than calcareous.

Definitely recorded elsewhere in North America in only one or two localities, but doubtless more widely distributed and overlooked or referred elsewhere. A North American subspecies.

3c. *Rinodina sophodes confragosa* (Ach.) Tuck. Gen. Lich. 123. 1872.

Parmelia confragosa Ach. Meth. Lich. Suppl. 33. 1803.

Thallus rather coarse, commonly verrucose and sometimes sublobate, whitish; apothecia becoming middle-sized; spores in ours possibly surpassing 30 μ in length.

This does not agree very closely with the published descriptions, and must be regarded as a provisional disposition.

Collected at Snowbank Lake. On old wood, though more commonly a rock lichen.

Elsewhere in North America, definitely reported from Illinois, California, Ontario, and Vancouver Island. Known also in Europe, Asia, and Africa.

3d. *Rinodina sophodes exigua* (Ach.) Tuck. Syn. N. A. Lich. 1: 208. 1882.

Lichen exiguus Ach. Lich. Suec. 69. 1798.

Thallus small, sometimes becoming scurfy or disappearing; apothecia minute or smaller than usual, the disk becoming convex, the thalloid exciple becoming crenulate and disappearing; spores rather small, frequently more than 8 in each ascus, in ours sometimes reaching 30.

Generally distributed over the State. On trees and old wood.

Found in all portions of North America. Known also in all of the grand divisions except Asia.

4. *Rinodina bischoffii* Koerb. Par. Lich. 75. 1865.

Thallus composed of small granules, these running together to form a usually thin, more or less chinky, scurfy, or rarely subareolate crust, this either scattered or continuous and spread irregularly over rather small areas of the substratum, in some of ours becoming thicker and in others tending to disappear; from whitish to sea-green or brownish; apothecia small or subminute, 0.4 to 0.8 mm. in diameter, sessile, the disk dark brown and becoming blackish, flat or somewhat convex, the thalloid exciple entire and persistent, but rarely blackening, a thin proper exciple within the thalloid one; hypothecium commonly pale; hymenium pale below and brownish above; paraphyses somewhat coherent, simple or rarely branched toward the commonly enlarged and brownish apex; asci clavate or ventricose-clavate; spores ovoid-ellipsoid, 15 to 20 μ long and 8 to 13 μ wide, the wide interval between the two cells indicated usually by a dark band.

Doctor Koerber recognized two subspecies, *protuberans* and *immersa*, the former with distinct thallus and elevated-sessile apothecia, the other with both thallus and apothecia more or less immersed in the substratum. Ours corresponds to the former.

Collected at Mankato, at Morton, and in the Leaf Hills. On calcareous rocks and pebbles. No doubt occurring on such substrata elsewhere in the State.

Elsewhere in North America in Illinois, Iowa, Kansas, Texas, and the Rocky Mountains. Known also in Europe and Africa.

5. *Rinodina lecanorina* Mass. Sched. Crit. Lich. Exsicc. 48. 1855.

Mischoblastia lecanorina Mass. Ric. Lich. 41. f. 70. 1852.

Thallus composed of flat or somewhat convex areoles, these small to middle, sized, 0.3 to 1.5 mm. across, and usually widely spread over the substratum as a continuous or more or less broken crust; sea-green varying toward olivaceous; apothecia small or minute, 0.3 to 0.8 mm. in diameter, immersed one or more in each areole, or in ours becoming more or less superficial upon the rather poorly developed thallus and showing a thalloid exciple, which finally disappears, the disk flat or convex, dark brown or black in color, usually rounded but sometimes more or less irregular; hypothecium pale; hymenium pale below and brownish above; paraphyses simple or branched; asci clavate; spores oblong or oblong-ellipsoid, 15 to 21 μ long and 9 to 10 μ wide.

Reported from Mankato, Oak Island, Koochiching, and Rainy Lake City. On granitic rocks. Our plants differ from European material in the poorer thallus development and more superficial apothecia. Doctor Zahlbruckner has named, but as yet not described, *Rinodina ioensis*, from Fayette, Iowa, which some of our material externally quite as much resembles as it does *R. lecanorina*.

Not known elsewhere in North America. Found in Europe.

6. *Rinodina nigra* Fink, Minn. Bot. Stud. 2: 695. 1901.

Thallus of moderate thickness, composed of flat or somewhat concave areoles, each areole 0.5 to 1 mm. in diameter, without cortex, dark slate-color, commonly irregular and spread as a continuous or more or less broken layer over larger or smaller areas

of the substratum; apothecia minute, 0.15 to 0.4 mm. in diameter, immersed and circular or more or less irregular in form, 1 to 3 in each areole, the disk black, flat, and somewhat depressed, the thalloid exciple entire; hypothecium pale; hymenium pale beneath and dark brown above; paraphyses simple or rarely branched, commonly somewhat enlarged and brownish toward the apex; asci clavate; spores oblong-ellipsoid, 9 to 15 μ long and 5 to 8 μ wide, often somewhat constricted at the septum.

Collected at Battle Lake. On granite.

A North American lichen, not known elsewhere.

PHYSCIA Ach. Lich. Suec. 3, 170, 255. 1798.

The thallus is usually foliose, but a few species rise to the fruticose condition, while at least one is possibly nearer the crustose type. In the foliose species the thallus shows the upper and lower cortices well developed, though in a number of species there is a pseudocortex of entangled hyphæ instead of a cellular one; and in these species this pseudocortex is usually much better developed on the upper side. In our fruticose *Physcia ciliaris* the pseudocortex is scarcely developed on more than one side. On the whole the cortex is better developed on the upper side, and in a given species one may find a well-developed cellular structure above and a tendency toward the pseudocortical condition below. Again, species showing the pseudocortex above may scarcely show any cortex whatever below. The algal and medullary layers occupy the usual positions for dorsiventral thalli, and the radial tendency is not evident even in our fruticose species. Rhizoids and cilia are common structures in the genus. Spermatogones are conspicuous on many of the thalli. The algal symbiont is *Cystococcus*.

The apothecia are sessile or subpedicellate on the upper surface of the thallus; the thalloid margin is entire, crenate, or variously irregular; the disk is usually brown when not pruinose, and more or less concave; the hypothecium is commonly pale or pale yellowish or brownish; the hymenium is pale, yellowish, or brownish; the paraphyses are simple or branched toward the apex, and the apex is most commonly enlarged and brownish; the spores are brown and 2-celled in all of ours.

The genus seems to be closely related to *Rinodina*, which also has the brown 2-celled spores. As a whole the thalli are quite different in the two genera, but the gap is easily bridged by such forms as *Physcia adglutinata* and *Rinodina sophodes*.

Fifteen distinct forms have been noted in the State, and some of them need further study, for though common and conspicuous, neither our *Physcias* nor those of North America generally are well understood.

Physcias occur on trees, rocks, old wood, over mosses, and rarely on the earth.

Type species *Physcia fastigiata* (Pers.) Ach. op. cit. 175, 255.

But this is *Ramalina calicaris* (L.) Fr. Thus *Physcia* takes precedence over *Ramalina*, being the earlier name. But the final status of both names must wait upon the typification of all lichen genera.

KEY TO THE SPECIES.

Section I. Cortical layer composed of entangled hyphæ.

Thallus fruticose, ascending or pendent..... 3. *P. ciliaris*.

Thallus foliose.

Thallus sea-green, adnate with ascending margin; white below.

Margin powdery-soresiate; exciple subentire or crenulate.....

1. *P. speciosa*.

Margin rarely soresiate; exciple crenate or crenate-foliate.....

2. *P. hypoleuca*.

Thallus usually brownish, with scarcely ascending margins.

Thallus bearing isidioid branchlets above, the lobes often fringed; exciple often similarly lobulate-fringed. 4a. *P. aquila detonsa*.

Thallus not isidioid nor lobulate-fringed; exciple crenate 4. *P. aquila*.

Section II. Cortical layer cellular.

Thallus ascending, at least the outer lobes.

Thallus more or less ascending, with lobes inflated and open at the ends..... 8. *P. hispida*.

Thallus ascending toward the margins of the lobes.

Margins of the lobes strongly ascending, with erose and granulose edges; sea-green above, whitish below..... 7. *P. tribacia*.

Margins of the lobes usually ascending but only moderately so.

Thallus sea-green to brown, more or less white-pruinose above; brownish black below..... 5. *P. pulverulenta*.

Thallus sea-green to brown, interruptedly ascending at the pruinose margins; black below..... 5a. *P. pulverulenta leucoleiptes*.

Thallus closely adnate throughout.

Thallus sometimes or always whitish below.

Thallus always whitish below; sea-green, whitish, or brownish above..... 6. *P. stellaris*.

Thallus sometimes darkening below.

Thallus medium-sized, sorediate above; whitish or rarely darkening below..... 9. *P. caesia*.

Thallus small, granulose-crustose and obscurely lobed, very closely adnate (adglutinate); whitish or darkening below..... 11. *P. adglutinata*.

Thallus dark-colored below.

Exciple ciliate on the lower side, or over the whole outer side.

Thallus saffron-colored within..... 10a. *P. obscura endochrysea*.

Thallus white within..... 10. *P. obscura*.

Exciple naked..... 6a. *P. stellaris apolia*.

1. *Physcia speciosa* (Wulf.) Nyl. Act. Soc. Linn. Bord. 21: 307. 1856.

Lichen speciosus Wulf. in Jacq. Coll. Bot. 3: 119. 1789.

Thallus one of the largest of the genus, 3.5 to 10 cm. in diameter, smooth, quite closely adnate with frequently more or less ascendant margins, commonly stellate, the lobes usually elongated, narrow, subdichotomous, with edges usually and upper surface rarely more or less sorediate; light or darker sea-green, beneath whitish with rhizoids of the same color, the pseudocortex poorly developed below and frequently wanting over part of the lower surface; apothecia small to middle-sized, 2 to 6.5 mm. in diameter, subsessile, the disk brown and usually deeply concave, the margin crenulate or subentire; hypothecium pale or yellowish; hymenium pale throughout; paraphyses simple or rarely branched toward the apex, slender, the apices pale and scarcely thickened; asci clavate or rarely cylindrico-clavate; spores oblong to ellipsoid, 23 to 34 μ long and 12 to 15 μ wide.

Found in all portions of the State, but scarcely common. On trees and mossy rocks. Usually sterile.

Distributed throughout the northeastern United States, northward and farther south in the mountains. Known in all of the grand divisions.

2. *Physcia hypoleuca* (Ach.) Tuck. Syn. N. A. Lich. 1: 68. 1882.*Parmelia speciosa hypoleuca* Ach. Syn. Lich. 211. 1814.

Thallus not surpassing 80 mm. in diameter in any specimen examined, yet probably on the whole rather larger than that of the last, quite closely adnate with margins frequently more or less ascendant, smooth, commonly stellate, the lobes long and rather narrow, on the whole quite similar to those of the last but rather more rigid with the margins very rarely sorediate; sea-green, beneath usually white and without cortex, clothed more or less with black rhizoids; apothecia middle-sized to large, 4 to 8 mm. in diameter, frequently numerous, subpedicellate, the disk dark brown to black, deeply concave and surrounded by a crenate or crenate-foliate margin; hypothecium pale or yellowish; hymenium pale below and brownish above; paraphyses simple or branched toward the enlarged and usually brownish apices; asci clavate; spores oblong to ellipsoid, 22 to 35 μ long and 12 to 16 μ wide, on the whole smaller than the measurements usually given.

Rare about Minneapolis and once collected at Bemidji. Not known elsewhere in the State, though the plant is surely distributed throughout the southeastern portion.

The North American distribution is about the same as that of the last species, with which the present one is closely related. I do not find the species recorded for Europe, though it is known to all the other grand divisions.

3. *Physcia ciliaris* (L.) Ach. Lich. Suec. 173, 255. 1798.

PLATE 47, A.

Lichen ciliaris L. Sp. Pl. 1144. 1753.

Thallus fruticose, caespitose, ascending, or pendent, varying in color from whitish to brownish on the convex pseudocorticate side and whitish on the commonly channeled and ecorticate side, the lobes elongated, 10 to 35 mm. in length, narrow and frequently showing a rounded condition, 0.5 to 2 mm. in width, much branched and usually becoming entangled, the convex side covered with trichomatic hyphae which give frequently a downy appearance under a magnifier, the edges bearing frequent cilia, especially toward the ends of the lobes; apothecia small to middle-sized, 2 to 4.5 mm. in diameter, short-pedicellate, the disk whitish-pruinose or rarely naked and brown, more or less concave, the margin subentire to crenate or more or less toothed-ciliate; hypothecium pale or yellowish; hymenium pale below and brownish above; paraphyses simple or rarely branched toward the apex, slender, the apices sometimes thickened and brownish; asci clavate or cylindrico-clavate; spores oblong to ellipsoid, 31 to 42 μ long and 15 to 21 μ wide.

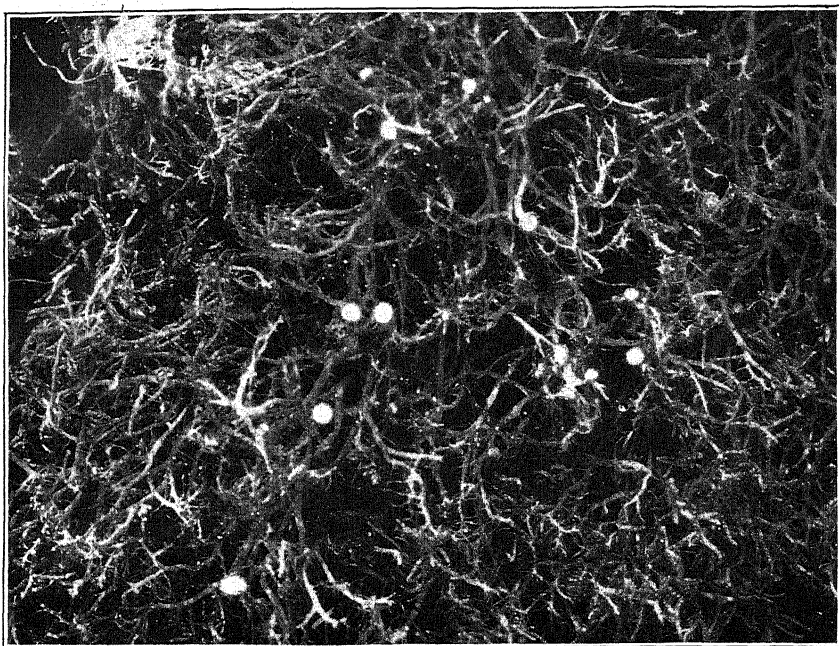
Collected at several points on the north shore of Lake Superior and at Fowl Lake along the international boundary. On rocks.

Frequent along the shores of the Great Lakes, in the mountains to the east and west, and northward. Known in all the grand divisions except Australia.

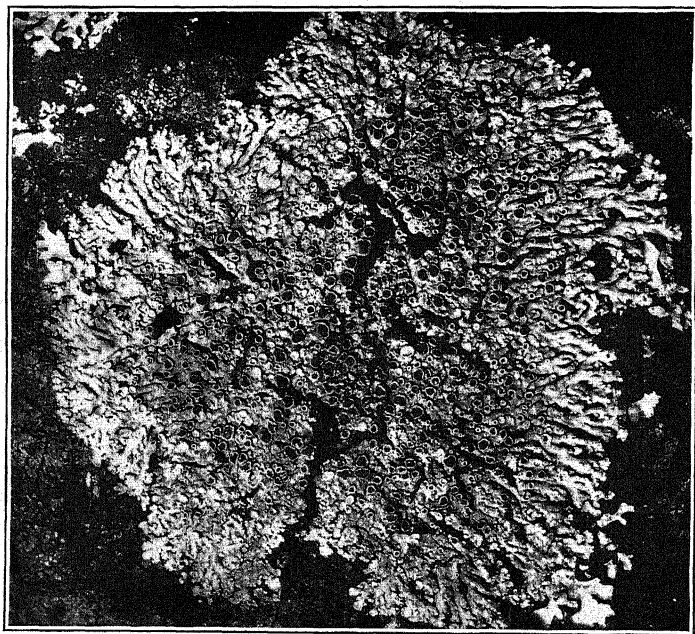
EXPLANATION OF PLATE 47.—Plant of *Physcia ciliaris* on rocks, showing the fruticose thallus and the apothecia. B. Plant of *Physcia stellaris* on a tree trunk, showing the apothecia and the characteristic lobing of the closely adnate foliose thallus. A enlarged $1\frac{1}{4}$ diameters; B, $1\frac{1}{3}$ diameters.

4. *Physcia aquila* (Ach.) Nyl. Act. Soc. Linn. Bord. 21: 309. 1856.*Lichen aquilus* Ach. Lich. Suec. 109. 1798.

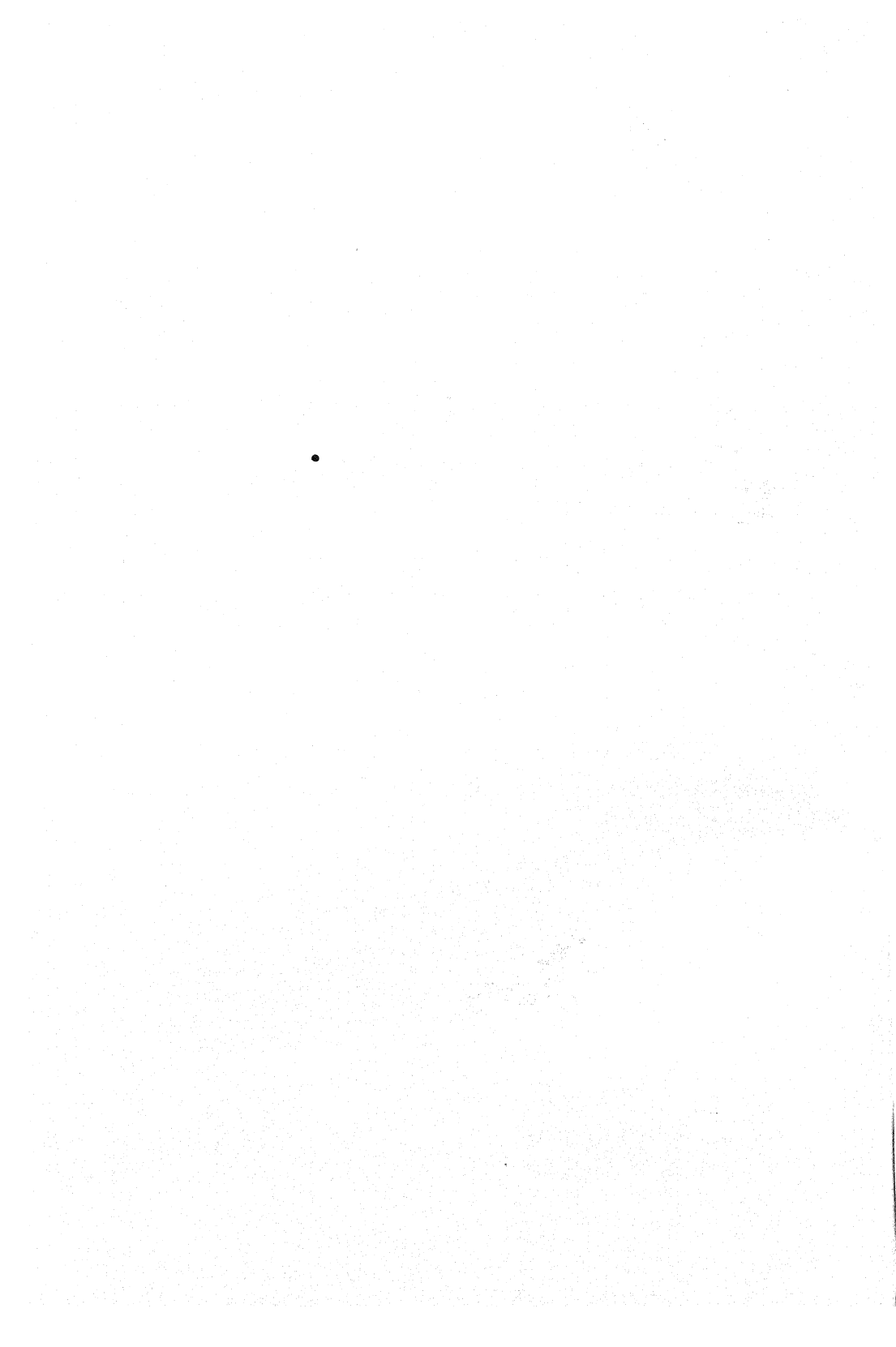
Thallus quite closely adnate, the margins scarcely ever ascendant, the upper surface smooth, stellate, the lobes usually elongated and narrow, subdichotomously much branched, imbricate, those of the center frequently more crowded and narrower, those of the circumference then wider, the sides of the lobes entire or wavy and the ends of the larger ones often crenate, sea-green or more often brownish, below pale with rhizoids of the same color or darkening, the lower pseudocortex less developed than the upper but usually continuous; apothecia rather small, 1.5 to 3.5 mm. in diameter, sessile, the disk brown to brownish black, concave, flat or even convex, the margin usually crenate; hypothecium yellowish or pale; hymenium pale beneath and



A. *PHYSCIA CILIARIS* (L.) ACH.



B. *PHYSCIA STELLARIS* (L.) NYL.



pale or brownish above; paraphyses rarely branched toward the apex, this seldom thickened or colored; asci clavate or cylindrico-clavate; spores oblong to ellipsoid, frequently curved, 28 to 43 μ long and 16 to 22 μ wide.

A rare plant in Minnesota, collected in the northern portion of the State at Two Harbors, Tower, and Harding.

Little is known of the North American distribution. Reported from California and from Florida, otherwise apparently confined to the northern United States and northward, and much less common than the subspecies below. Possibly all of our Minnesota material could be referred to the subspecies, but undoubted specimens of the type have been found as near Minnesota as northeastern Iowa. Known also in Europe and Asia.

4a. *Physcia aquila detonsa* (Fr.) Tuck. Syn. N. A. Lich. 1: 71. 1882.

Parmelia detonsa Fr. Syst. Orb. Veg. 284. 1825.

Thallus pale or darker brown, rarely isidioid or much more frequently the lobes fringed with small lobules; the borders of the apothecia also frequently fringed with similar lobules. Internally like the above.

Number 1024 from Koochiching shows exciples externally ciliate, a character not seen in descriptions.

This is the usual form in Minnesota and, though by no means common, is generally distributed over the State. On trees and rarely on rocks.

Distributed throughout the eastern half of the United States and northward. Also known in Japan.

5. *Physcia pulverulenta* (Schreb.) Nyl. Act. Soc. Linn. Bord. 21: 308. 1856.

Lichen pulverulentus Schreb. Spic. Fl. Lips. 128. 1771.

Thallus medium-sized but sometimes large, 2.5 to 6 cm. in diameter, but rarely reaching 10 cm., usually closely adnate but with margins occasionally somewhat ascendant, stellate; the upper surface smooth, the lobes sometimes quite elongated and narrow, with ends rounded or crenate; sea-green to brown or completely or interruptedly white-pruinose, beneath variously colored but usually brownish black and lighter toward the margin, the numerous rhizoids black or brown, or lighter toward the margins; apothecia small or middle-sized, 2.5 to 5 mm. in diameter, sessile, the disk flat or concave, and dark brown or subpruinose, the margin entire, crenate or irregularly lobed; hypothecium pale or yellowish; hymenium pale below and pale or brownish above; paraphyses simple or rarely branched toward the apex, which is sometimes thickened and brownish; asci clavate; spores oblong to ellipsoid, 22 to 40 μ long and 12 to 20 μ wide.

Generally distributed over the State. On trees, old wood, or rocks, or rarely over mosses on earth.

Found in some form throughout North America. Known to all of the grand divisions except Australia and South America.

5a. *Physcia pulverulenta leucoleiptes* Tuck. Syn. Lich. N. E. 32. 1848.

Lobes more flattened, interruptedly elevated and pruinose at the margins, beneath black.

Found only in the extreme northern portion of the State. On trees and rocks.

Recorded from several widely separate North American localities and doubtless as widely distributed as the species. I find no record of the plant in foreign lands.

6. *Physcia stellaris* (L.) Nyl. Syn. Meth. Lich. 1: 424. 1858.

PLATE 47, B.

Lichen stellaris L. Sp. Pl. 1144. 1753.

Thallus, medium-sized, 20 to 85 mm. in diameter, closely adnate, stellate, the upper surface commonly smooth, the lobes frequently elongated and much branched, the ends rounded or crenate, more or less imbricate and frequently crowded into a

roughened crust toward the center, sea-green varying toward whitish or brownish, beneath whitish with rhizoids of the same color; apothecia small, 1.5 to 3.5 mm. in diameter, sessile, the disk flat or slightly concave or convex, dark brown to black or whitish-pruinose, the margin entire or crenulate; hypothecium pale or yellowish or brownish; hymenium pale or brownish, the latter especially above; paraphyses simple or more commonly branched, enlarged and brownish toward the apex; asci clavate or long-clavate; spores oblong to ellipsoid, 15 to 24 μ long and 8 to 11 μ wide.

Generally distributed over the State. On trees and rocks.

The plant is distributed throughout North America and is cosmopolitan in its foreign distribution.

EXPLANATION OF PLATE 47.—See page 226.

6a. *Physcia stellaris apiolia* (Hoffm.) Nyl. Not. Sällsk. Faun. Flor. Fenn. 5: 111. 1861.

Lobaria apiolia Hoffm. Deutsch. Fl. 2: 152. 1795.

Thallus darker below and becoming black with rhizoids of the same color; apothecia seldom pruinose and more commonly showing a crenulate or even crenate margin.

Distributed throughout the State. On igneous and metamorphic rocks. The darkened condition below has been observed in tree forms as well.

The American distribution seems to be the same as that of the species. Known also in Europe.

7. *Physcia tribacia* (Ach.) Nyl. Flora 64: 537. 1881.

Parmelia tribacia Ach. Lich. Univ. 415. 1810.

Thallus closely adnate, but the margins of the lobes strongly ascendant, orbicular or more commonly occurring in large irregular patches, sometimes forming a subcontinuous granular crust toward the center, when having a definite outline small to middle-sized, 20 to 75 mm. in diameter, the lobes short and imbricated with erose-granulose, or rarely crenate edges, usually wide in proportion to length, but rarely more branched, elongated and narrower; sea-green, below whitish with scattered fibrils of the same color; apothecia small, 1.5 to 2.5 mm. in diameter, sessile or subsessile, the disk flat or slightly concave, black or blackish brown or sometimes whitish-pruinose, the margin entire or crenulate; hypothecium yellowish; hymenium pale or slightly brownish below and sometimes darker brownish above; paraphyses simple or rarely branched toward the commonly enlarged and brownish apex; asci clavate or cylindrico-clavate; spores oblong to ellipsoid, 16 to 23 μ long and 7 to 10 μ wide.

The plant is generally distributed over the State and is easily known in its peculiar forms by the thallus. Such forms, however, as number 580, from Blueberry Island, with much elongated and narrowed lobes will probably eventually have to be separated. But the last is connected with the usual form of the species by such intermediate forms as number 571 from the same island. On trees and rocks, and the tree forms commonly somewhat more closely adnate and less imbricated.

Distributed throughout North America and also well known in Europe.

8. *Physcia hispida* (Schreb.) Tuck. Syn. N. A. Lich. 1: 75. 1882.

Lichen hispidus Schreb. Spic. Fl. Lips. 126. 1771.

Thallus small, 6 to 28 mm. in diameter, but quite inclined to grow in dense clusters covering larger areas, sometimes subadnate and stellate but more commonly ascendant and diffusely caespitose, the lower cortex scarcely continuously cellular, the lobes usually somewhat elongated, imbricated, and branched, the apices rounded or crenate, swollen toward the ends by a large air space between the medullary tissue and the lower cortex, usually open upwardly, making the air space a terminal cavity, clothed more or less throughout with long, commonly dark fibrils; sea-green, beneath white and clothed more or less with light or darker rhizoids; apothecia small, 1 to 2.5 mm.

in diameter, sessile or subsessile, the disk flat or slightly concave, commonly whitish-pruinose but sometimes naked and dark brown, the margin entire or crenulate; hypothecium pale or yellowish; hymenium pale below and brownish above; paraphyses simple, or branched toward the usually enlarged and brownish apex; asci clavate; spores oblong-ellipsoid, 12 to 18 μ long and 6 to 9 μ wide.

Common in the northern portion of the State, but usually sterile. On trees and rarely on rocks.

Distributed throughout the northern United States, in cold portions, and British America. Known also in Europe and Africa.

9. *Physcia caesia* (Hoffm.) Nyl. Act. Soc. Linn. Bord. 21: 308. 1856.

Lichen caesius Hoffm. Enum. Lich. Icon. 65. pl. 12. f. 1. 1784.

Thallus medium-sized, 18 to 80 mm. in diameter, closely adnate, stellate, the upper surface bearing rounded gray soredia, the lobes usually quite elongated and branched, the ends rounded or crenate, more or less imbricated; light sea-green, beneath whitish or rarely blackening with usually dark rhizoids; apothecia small, 1.5 to 4 mm. in diameter, sessile, the disk flat or slightly concave, dark brown to black or rarely gray-pruinose, the margin entire or crenulate; spores 15 to 23 μ long and 8 to 12 μ wide.

Ours rarely fruited, the apothecial and spore characters taken from Tuckerman.

No doubt generally distributed over the State, some of the material referred to *Physcia granulifera* in the first four papers of the preliminary survey belonging here. On the other hand, some of the specimens referred to here in the same papers will have to be placed elsewhere eventually, as they are small, narrow-lobed plants and usually devoid of soredia. On rocks and rarely on trees.

No doubt generally distributed over northern United States, at least east of the Rocky Mountains, and extending into British America and Alaska, but little known and confused with other species. Also known in Europe, Asia, and Africa.

10. *Physcia obscura* (Schaer.) Nyl. Act. Soc. Linn. Bord. 21: 309. 1856.

Parmelia obscura Schaer. Enum. Lich. Eur. 36. 1850.

Thallus closely adnate except on mosses, commonly stellate, the upper surface smooth or rarely roughened, rarely sorediate, the lobes commonly long and dichotomously much branched, the ends rounded or crenate, more or less imbricated and frequently passing toward the center into a subcontinuous crust usually composed of closely packed and imbricated lobules, rarely ciliate along the margins; sea-green varying toward brownish or more rarely toward ash-color, middle-sized, 20 to 80 mm. in diameter, beneath black with black rhizoids or the surface and rhizoids rarely lighter-colored; apothecia small or rarely larger, 1.5 to 4 mm. in diameter, sessile, the disk flat or slightly concave, reddish brown to black, or possibly rarely subpruinose, the margin entire or rarely crenulate, the lower side or rarely the whole outer surface of the exciple more or less ciliate; hypothecium brownish; hymenium pale, or brownish above; paraphyses slender, simple or branched toward the usually thickened and brownish apex; asci clavate; spores oblong to ellipsoid, 17 to 24 μ long and 8.5 to 12 μ wide.

Generally distributed over the State. On trees, rocks, and old wood, and over mosses.

Found in all portions of North America in some form. Known in all the grand divisions.

10a. *Physcia obscura endochrysea* (Hampe) Nyl. Act. Soc. Sci. Fenn. 7: 440. 1863.

Parmelia endochrysea Hampe; Nyl. Syn. Meth. Lich. 1: 427. 1858.

Thallus more or less saffron-colored within, the peculiar coloration frequently extending to the hypothecium and the thalloid exciple, but seldom to the hymenium.

Collected on rocks at Rainy Lake City, Harding, and Tower. Doubtless more widely distributed in the northern portion of the State.

I have a specimen from New York and one from New Hampshire. No further definite information as to North American distribution is at hand. Known also in South America, Europe, and Asia.

11. *Physcia adglutinata* (Floerke) Nyl. Syn. Meth. Lich. 1:428. 1858.

Lecanora adglutinata Floerke, Deutsch. Lich. 4: 7. 1815.

Thallus small and thin, 12 to 35 mm. in diameter, or irregularly scattered over the substratum, closely adnate or even adglutinate, the lobes usually elongated and branched, but closely crowded and difficult to trace, the ends rounded or crenate, toward the center disappearing for the most part in a granulose crust; sea-green varying toward ashy or brownish, below whitish or sometimes darker, rarely bearing scattered rhizoids; apothecia small, 0.45 to 1.75 mm. in diameter, sessile, the disk flat, blackish brown, the margin entire or subcrenulate, scarcely ciliate; hypothecium pale brownish; hymenium pale below and brownish above; paraphyses commonly branched toward the enlarged and usually brownish apex; asci clavate; spores ellipsoid or oblong, 13 to 21 μ long and 7 to 9.5 μ wide.

Found in several widely separate localities in the State and no doubt generally distributed, though easily overlooked or confused with small forms of the last species. On trees.

Generally distributed over North America except perhaps at the extreme north. Known also in South America, Europe, and Asia.

PYXINE Fr. Syst. Orb. Veg. 267. 1825.

The thallus is foliose, closely adnate or even adglutinate, more or less lobed and imbricated, and has a more or less developed cellular cortex above, but none beneath, while the algal and medullary layers are well developed and in the usual position for dorsiventral thalli. The lower surface is more or less clothed with dark rhizoids, and the hyphae of the lower side of the thallus are also black or blackish, thus coloring the whole lower surface. Soredia are very common on the upper surface in our single species. The algal symbiont is *Cystococcus*.

The apothecia are sessile on the upper surface of the thallus. They are rather small in size and possess a thalloid exciple inclosing a brown or blackish proper one. The thalloid exciple, especially in our species, is likely to become blackened, in which case the apothecium has a lecideoid appearance externally. The hypothecium is more or less cellular and brown or blackish brown. The hymenium is commonly pale-brownish. The paraphyses are commonly simple, with the apex thickened and brownish. The spores are 2-celled and brown, though undoubted members of the genus show 4-celled conditions.

Pyxine is closely related to *Physcia*, though the deceptive lecideoid appearance of the apothecium frequently obscures the relationship in some of the species. Like the latter species, Pyxine is also closely related to *Rinodina*.

The species are mostly southern, and only a single one occurs in Minnesota.

The plants commonly occur on trees, but are found less often on rocks.

Type species *Lecidea sorediata* Ach. Syn. Meth. Lich. 54. 1814. (*Pyxine sorediata* (Ach.) Fr.)

***Pyxine sorediata* (Ach.) Fr. in Sagra, Hist. Cuba 9: 124. 1845.**

PLATE 48.

Lecidea sorediata Ach. Syn. Meth. Lich. 54. 1814.

Thallus medium-sized or larger, 6.5 to 15 cm. in diameter, closely adnate, smooth or wrinkled, usually orbicular in outline, the lobes somewhat elongated, subdichotomously branched, more or less imbricated, the ends rounded or crenate, usually covered more or less with white or gray soredia; sea-green or varying toward ashy or olivaceous, beneath black, or lighter toward the margin, with rhizoids of the same colors, commonly more or less sulphur-colored within; apothecia rather small, 0.75



PYXINE SOREDIATA (ACH.) FR.

to 1.5 mm. in diameter, the disk commonly convex and black but rarely white-pruinose, the thalloid margin only noticeable in the early development, the margin later becoming blackened and the whole apothecium having an external lecideoid appearance; hypothecium more or less cellular, brown or blackish-brown; hymenium pale-brownish; paraphyses simple or rarely branched, thickened and brownish toward the apex; asci clavate; spores brown, 2-celled, oblong to ellipsoid, 17 to 28 μ long and 7 to 10 μ wide.

Widely distributed in the State, but not common in any portion. On trees and rarely on rocks.

Well known in North America, except in the extreme north and west. Distributed throughout the grand divisions.

EXPLANATION OF PLATE 48.—Plant on white cedar bark, showing the sorediate thallus. Natural size.

URCEOLARIA Ach. Lich. Suec. 1, 30, 258. 1798.

The thallus is strictly crustose and commonly becomes quite thick. The surface is usually distinctly areolate or verrucose, the areoles or verrucae often becoming quite convex and prominent. There is what may be regarded as a poorly developed upper pseudocortex of entangled hyphae, and below this the algal and medullary layers are somewhat differentiated. There is no showing of a lower cortex; hyphal rhizoids are quite numerous as attaching organs. The algae are a form of *Cystococcus*, the cells often occurring solitary instead of being united in larger or smaller groups as is the more common condition of *Cystococcus* cells in lichen thalli. Sea-green, ashy and whitish are the common colors of the thallus.

The apothecia are commonly small or minute, but may reach middle-size in some of the species. They are more commonly scattered and 1, 2, or 3, in each areole, but sometimes they become more numerous with several to each areole. They are commonly immersed in the thallus, and the disk is more or less urceolate. There is a usually dark exciple and hypothecium, and surrounding the proper exciple almost always a thalloid one. The hymenium is pale or brownish. The paraphyses are simple or rarely branched. The spores are muriformly many-celled and become brown when mature, the brown spores commonly being smaller and doubtless past their prime.

The relationships of the genus are so obscure as to make any arrangement appear somewhat artificial and subject to criticism. The apothecium is in the main open, though in some of the species there is certainly an approach to the true perithecium. The spores are clearly nearest to those of *Rhizocarpon* or *Staurothele*, and the dark exciple and hypothecium look in the same direction. However, the thallus and the usual presence of a thalloid exciple seem to bring the *Urceolarias* near to the *Rinodinas* or the *Lecanoras*. On the whole it has appeared best to place the genus nearer to *Rinodina*.

Tuckerman admits two North American species, both of which have been met in the State. On rocks, and rarely on earth and old wood.

Type species *Urceolaria agelea*. Ach. loc. cit. This plant has been placed under *Phlyctis* Wallr. by the best European lichenists and surely falls outside the present conception of *Urceolaria*, which should replace *Phlyctis*.

KEY TO THE SPECIES.

- Proper exciple denticulate..... 1. *U. scruposa*.
Proper exciple radiate-striate..... 2. *U. actinostoma*.

1. *Urceolaria scruposa* (Schreb.) Ach. Lich. Suec. 32, 258. 1798. FIGURE 16.

Lichen scruposus Schreb. Spic. Fl. Lips. 133. 1771.

Thallus suborbicular and occurring in medium-sized or large patches, 4 to 15 cm. across, or irregular and variously spread over the substratum, thickened and verru-

cose or passing into areolar conditions, the verrucæ or areoles becoming much raised, giving the thallus a roughened surface; sea-green, ashy or whitish; apothecia commonly immersed, but becoming adnate, especially when the thallus is thin, small or minute, 0.3 to 1 mm. in diameter, the disk urceolate and black or grayish-pruinose, the more or less denticulate and dark-colored proper exciple often hidden by the

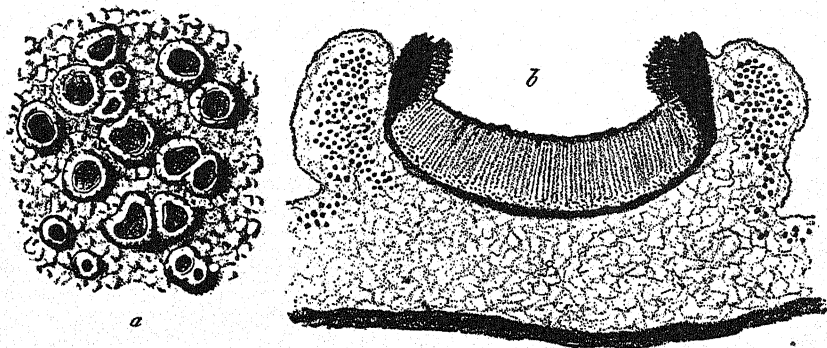


FIG. 16.—*Urceolaria scruposa*. *a*, Portion of a thallus with several apothecia; *b*, section of an apothecium showing a proper exciple within a thalloid one. *a*, Enlarged 3 diameters; *b*, 50 diameters. From Reinke.

thalloid one, or the latter disappearing more or less and the former becoming prominent; hypothecium commonly dark brown; hymenium pale or brownish below and brownish or brown above; paraphyses simple or rarely branched, sometimes enlarged and brownish toward the apex; asci cylindrical or cylindrico-clavate; spores oblong-ellipsoid, muriformly many-celled, 20 to 28 μ long and 10 to 15 μ wide.

Generally distributed over the State. On rocks and rarely on earth and old wood.

Widely distributed in North America. Known also in all of the grand divisions.

2. *Urceolaria actinostoma* (Pers.) Tuck. *Gep. Lich.* 135. 1872.

Verrucaria actinostoma Pers.; Ach. *Lich. Univ.* 288. 1810.

Thallus at first smoothish but becoming somewhat verrucose-roughened and finally plainly areolate, the areoles or verrucæ smaller and flatter than in the last, of the same colors and spread over the substratum in much the same way, though scarcely so large or so widely spread; apothecia minute and immersed, the disk dark and opening by a pore, or sometimes somewhat open and more properly disk-like, the proper exciple dark and radiate-striate above, frequently gray-pruinose, the thalloid exciple commonly wanting; hypothecium usually dark brown; hymenium pale or brownish below and brownish or brown above; paraphyses simple or rarely branched, sometimes enlarged and brownish toward the apex; asci cylindrico-clavate; spores somewhat shorter and broader, 18 to 28 μ long and 11 to 18 μ wide.

Collected at Granite Falls. On granite.

Elsewhere in North America in Connecticut, South Carolina, Iowa, and Kansas. Known also in South America, Europe, and Asia.

Family VERRUCARIACEAE.

Considering apothecial structure of more importance than thallus structure, the present family, at least as represented in our flora by the genus *Verrucaria*, is the lowest of the Pyrenocarpaceae. This appears both in the short and commonly gelatinized and indistinct or disappearing paraphyses and in the uniformly simple spores. However, when we include *Thelidium* found elsewhere, we find spores that are not simple but still colorless. Zahlbruckner would also include *Staurothele* with its

muriform spores in the present family, but it has seemed better to place this genus in a higher position with the Endocarpaceae.

The thalli of the Verrucariaceae are surely better developed than those of the Pyrenulaceae, those of the former family being usually in part or largely above the substratum and verrucose or areolate, while those of the latter family are usually wholly or largely within the substratum and very rudimentary and inconspicuous.

The relationship of the Verrucariaceae to the Pyrenulaceae is certainly a very close one and, indeed, the older lichenists were in the habit of placing all the members of the two families in a single genus. However, it seems that the difference in character of thallus and spores, and more especially of the paraphyses, furnishes some ground for the separation into two families. Yet it is by no means clear that we have pursued the best plan in following some of the European lichenists into this subdivision.

It must be further stated that the present family is somewhat closely related to the Gyalectaceae through *Conotrema* and to the Physciaceae through *Urceolaria*. Probably the *Pertusarias* are more closely related to the *Arthopyrenias* and *Pyrenulas* than to the *Verrucarias*.

VERRUCARIA Scop. Intr. Hist. Nat. 61. 1777.

The thallus is crustose, on the whole not so rudimentary as that of *Sagedia*, *Arthopyrenia*, or *Pyrenula*, more conspicuous upon the substratum or more or less hypolithic, and never entirely disappearing, at least not in any of our species or others examined. In some of the species the thallus is quite smooth, but it is more commonly verrucose or areolate and usually widely spread over the substratum. The thallus color varies greatly, both white and black thalli and various intermediate colors occurring within the genus. Schneider^a finds *Pleurococcus* constantly present as the algal symbiont in all the species examined by him.

The apothecia are small or minute and are more or less immersed in the thallus and substratum. They are commonly globose, and the perithegium is black (brownish-black in section). The amphithegium is pale or finally more or less colored. The paraphyses are short and soon become gelatinized and coherent-indistinct. The asci also commonly become more or less gelatinized. The spores are simple in all members of the genus as defined by Schneider, though Tuckerman and Nylander both admitted to the genus lichens having quite various spore characters. Evidently the view of the latter must be revised, and we may follow that of Schneider.

The genus is somewhat closely related to *Arthopyrenia* and *Pyrenula*, but when the differences in spore characters, thallus development, and algal symbionts are considered, there seems at least to be no sufficient reason for placing the two genera together as has frequently been done.

Five species and subspecies occur in the State. On various rocks.

Type species *Lichen ericetorum* L. Sp. Pl. 1141. 1753. But this plant is, according to Wainio,^b identical with our *Icmadophila aeruginosa*. This makes the name *Verrucaria* invalid and subject to change in the revision of lichen genera.

KEY TO THE SPECIES.

- | | |
|--|------------------------|
| On earth: thallus thin, ashy or greenish, granulose, often disappearing..... | 1. <i>V. epigaea</i> . |
| On rocks. | |
| Thallus usually whitish; smooth and chinky, or scurfy or granulose..... | 2. <i>V. muralis</i> . |

^a Textb. Lich. 185.

^b Act. Soc. Faun. Flor. Fenn. 14: 20. 1888.

Thallus darker-colored.

Thallus ashy-gray to olivaceous or blackish, thick and becoming minutely areolate, with apothecia entirely immersed.....

3. *V. fuscella*.

Thallus olivaceous-greenish to dull black, thinner, chinky or rarely areolate; the apothecia not so completely immersed.

Thallus brownish black to dull black..... 4. *V. nigrescens*.

Thallus olivaceous-greenish 4a. *V. nigrescens viridula*.

1. *Verrucaria epigaea* (Pers.) Ach. Meth. Lich. 123. 1803.

Sphaeria epigaea Pers. Syn. Meth. Fung. App. xxvii. 1801.

Thallus a thin crust upon the substratum, ashy or greenish in color, often finely granulose, widely spread and sometimes disappearing; apothecia very minute, more or less immersed, the perithecium dark brown in section, the amphithecium commonly pale; paraphyses often quite distinct; asci cylindrical or cylindrico-clavate; spores oblong-ellipsoid, 16 to 28 μ long and 7 to 10 μ wide.

Collected in the northern portion of the State at Rainy Lake City, at Harding, and about Snowbank Lake. On earth.

Elsewhere in North America in Massachusetts, Maryland, Virginia, New Jersey, Illinois, Iowa, California, Quebec, and Newfoundland. Known also in Europe.

2. *Verrucaria muralis* Ach. Meth. Lich. 115. 1803.

Lichen muralis Ach. Lich. Suec. 60. 1798.

Thallus usually in part epilithic, smooth and chinky or becoming scurfy or slightly granulose, white, whitish, or darkening and widely spread over the substratum as a continuous or more or less broken layer, or the epiphloeodal portion disappearing; apothecia small or minute, but reaching larger sizes than in the last, 0.15 to 0.35 mm. in diameter, often becoming largely superficial and appearing as black spots upon the substratum, crowned by the minute ostiole, sometimes more or less clustered, the perithecium dark brown in section, the amphithecium pale or yellowish; asci cylindrico-clavate; spores oblong-ellipsoid, 13 to 23 μ long and 6 to 9 μ wide.

On calcareous rocks, and found in the State wherever these occur.

Elsewhere in North America in New England, New York, Vermont, Ohio, Illinois, Wisconsin, Iowa, Missouri, Kansas, California, and Canada. Known also in Europe and Asia.

3. *Verrucaria fuscella* (Turn.) Ach. Lich. Univ. 289. 1810.

Lichen fuscellus Turn. Trans. Linn. Soc. Lond. 7: 90. pl. 8. f. 2. 1804.

Thallus forming a rather thick layer over the substratum (often 0.4 to 0.7 mm. in thickness), occurring in small rounded or irregular areas or becoming more widespread, chinky and passing into minutely-areolate conditions, the surface ashy-gray varying toward olivaceous or blackish, usually black within, never disappearing; apothecia minute, usually completely immersed, frequently more than one in each areole, the perithecium dark brown in section, the amphithecium pale or becoming colored; asci clavate or cylindrico-clavate; spores ellipsoid, 9 to 14 μ long and 4 to 7 μ wide.

Generally distributed over the State, but most common in regions where calcareous rocks occur. On rocks, usually calcareous.

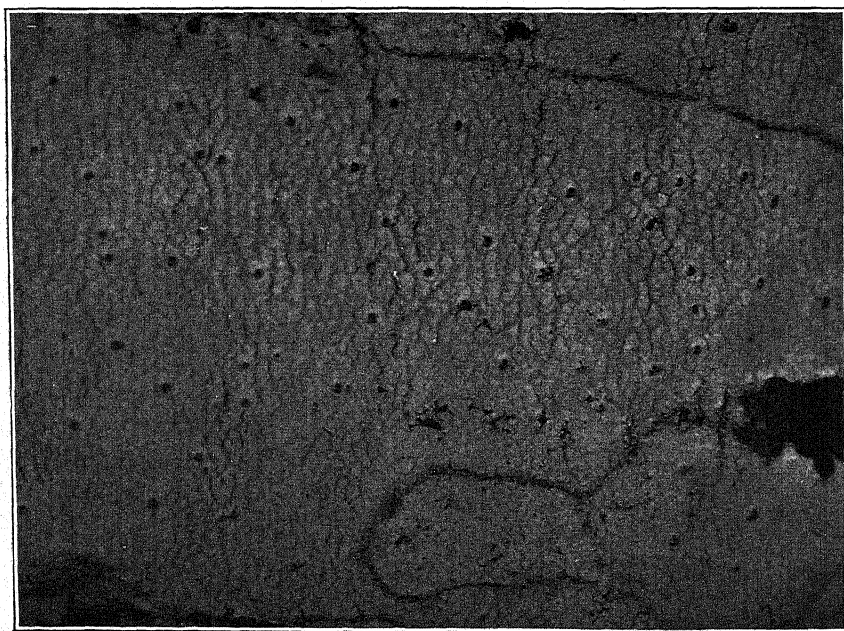
Elsewhere in North America in Vermont (?), Alabama, Wisconsin, Illinois, Iowa, California, and Alaska. Known also in Europe and Asia.

4. *Verrucaria nigrescens* Pers. Neu. Ann. Bot. Usteri 14: 36. 1795.

Thallus forming a continuous or more or less broken layer upon the substratum, thinner than in the last, chinky and rarely passing into distinctly areolate conditions, the surface ashy-gray, becoming blackish or black, the ashy-gray surface so frequently



A. *VERRUCARIA NIGRESCENS VIRIDULA* (SCHRAD.) NYL.



B. *PYRENULA LEUCOPLACA* (WALLR.) KOERB.

seen in the last; apothecia somewhat larger than in the last and not so completely immersed, the perithecium blackish-brown, the amphithecium pale or becoming brownish; asci clavate, or cylindrico-clavate; spores ellipsoid, larger than in the last, 15 to 24μ long and 6 to 10μ wide.

Distribution and habitat in the State the same as in the last.

Elsewhere in North America in New England, New York, Pennsylvania, Louisiana, Ohio, Illinois, Iowa, California, and Canada. Known also in Europe and Africa.

4a. *Verrucaria nigrescens viridula* (Schr.) Nyl. Mém. Soc. Acad. Maine et Loire 4: 23. 1858. PLATE 49, A.

Endocarpon viridulum Schrad. Spic. Fl. Germ. 192. pl. 2. f. 4. 1794.

Thallus olivaceous-greenish; spores larger, 20 to 32μ long and 10 to 13μ wide.

Widely distributed in the extreme northern portion of the State, probably being the common form upon the rocks of the region, while the species is common upon the calcareous rocks farther south.

Elsewhere in North America in Illinois and California. Known also in Europe, Asia, and Africa.

Verrucaria viridula and *Verrucaria viridula subfuscella* of the preliminary reports.

EXPLANATION OF PLATE 49.—A, Plant of *Verrucaria nigrescens viridula* on rocks, showing the apothecia in raised spots in the thallus. B, Plant of *Pyrenula leucoplaca*, showing the thin whitish epiphloeodal film of thallus and the apothecia partly embedded in the woody substratum. A enlarged $3\frac{1}{2}$ diameters; B, $3\frac{3}{4}$ diameters.

Family PYRENULACEAE.

The family is represented in our flora by the three genera *Sagedia*, *Arthopyrenia*, and *Pyrenula*. The thallus is crustose in all three and is rather better developed in the first genus than in the second and third, being there more often above the substratum and rather less frequently disappearing. However, in the last genus we find the higher spore development on the whole, and *Pyrenula* must consequently be regarded as the highest genus.

The paraphyses are better developed than in the *Verrucariaceae*, being longer and commonly remaining distinct, and the spores are as a whole of a higher type, ranging from 2-celled to muriform conditions and frequently showing color. In addition to the statement made in the description of the *Verrucariaceae* concerning the propriety of separating the present family from that may be added that the algal symbiont is different in the two families, being *Pleurococcus* in the *Verrucariaceae* and *Chroolepus* in the present family. This of itself may have little weight, but is worthy of consideration in connection with other differences. For the remainder of the argument the reader is referred to the description of the *Verrucariaceae*. The *Pyrenulaceae* are also somewhat closely related to the *Pertusariaceae*.

SAGEDIA Ach. Lich. Univ. 71, 327. pl. 6. f. 3-7. 1810.

The thallus is crustose, thin, smooth, slightly roughened, granulose, scurfy, chinky, subareolate, or even mainly or wholly hypophloeodal or disappearing. The structure is rudimentary without differentiation into layers, and the color varies from ashy through shades of greenish to brown or even blackish brown. The algal symbiont is apparently similar to that of the *Pyrenulas* and *Arthopyrenias*, but little could be made out in the scant thalli examined.

The apothecia may be quite superficial or more or less immersed in the thallus or substratum and are globose and inclosed in the exciple (perithecium), which is dark in color and well developed. The amphithecium is pale. The paraphyses are very slender and commonly distinct. The spores are hyaline, 4 to several-celled, and fusiform to acicular.

The genus is closely related to *Verrucaria*, *Arthopyrenia*, and *Pyrenula*, differing mainly in the spore characters, the more commonly distinct paraphyses, and the persistently pale amphithecium.

A single species has been found in the State. On cedar trees.

Type species *Sagedia depressa* Ach. loc. cit. The author has not been able to ascertain the status of this plant, but it is probably a *Pertusaria* or a *Verrucaria*.

1. *Sagedia oxyspora* (Nyl.) Tuck. Gen. Lich. 266. 1872.

Verrucaria oxyspora Nyl. Nya Bot. Not. 179. 1852.

Thallus very thin and slightly scurfy, ashy in color, or frequently entirely hypophloeodal or disappearing; apothecia minute, partly immersed in the substratum, globose-hemispherical, appearing as minute blackish spots crowned by the ostiole, the perithecium rather thin but commonly dark brown in section, the amphithecium cloudy or perhaps finally darkening; paraphyses slender, distinct, and commonly simple (Tuckerman states "separated from the type of *Sagedia* by the indistinct paraphyses"); asci long-clavate or fusiform; spores varying considerably, fusiform or acicular, frequently curved, 4 to 8-celled, the septa indistinct and the spores often remaining for a long time, simple, 20 to 34 μ long and 2 to 4 μ wide.

Generally distributed throughout the northern portion of the State. On birches and scarcely to be distinguished from certain *Pyrenulas* except in section.

Elsewhere in North America at New Bedford, Massachusetts, and in Newfoundland, Ohio, and Illinois. Known also in Europe.

ARTHOPYRENIA Mass. Ric. Lich. 165. f. 326-341. 1852.

The thallus is crustose and hypophloeodal, or rarely in part epiphloeodal. It frequently becomes wanting or so nearly so that it may be easily overlooked in the best sections of the substratum. The epiphloeodal portion is at best a very thin film and is usually quite smooth. The thallus is irregularly and often widely spread over the substratum, and may usually be distinguished from the general surface of the substratum by its faint or more conspicuous whitish or ashy color. On account of the inconspicuous and often evanescent character of the thallus, members of the genus have frequently been regarded as pyrenomycetous fungi. But a study of a large number of specimens will in nearly every instance demonstrate the presence of a thallus containing algal cells.

The apothecia are black in ours and are of the same general form, size, and structure as those of the *Verrucarias*, with similar amphithecium and perithecium. They are more or less sunken in the substratum. The paraphyses are simple or branched, and are usually more or less gelatinized and coherent-indistinct. The spores are hyaline ellipsoid-oblong to linear-oblong, and the number of cells varies from 2 to several.

The members of the genus are closely related to the *Verrucarias* as well as to other genera of the *Pyrenulaceae*.

Six species and subspecies have been found in the State. On trees, except one from rocks doubtfully admitted here.

Type species *Arthopyrenia analepta* (Ach.) Mass. loc. cit.

KEY TO THE SPECIES.

- | | |
|--|---|
| On rocks; spores 2-celled, 13 to 20 μ long | 3. <i>A. conoidea</i> . |
| On trees. | |
| Spores 2-celled. | |
| Spores 32 to 60 μ long | 1. <i>A. macrospora</i> . |
| Spores 12 to 18 μ long | 2. <i>A. gemmata</i> . |
| Spores more than 2-celled. | |
| Spores becoming obscurely muriform..... | 5a. <i>A. punctiformis</i> fal-
lax. |
| Spores never muriform. | |
| Spores 2 to 4-celled..... | 5. <i>A. punctiformis</i> . |
| Spores 6 to 8-celled..... | 4. <i>A. quinquesepata</i> . |

1. *Arthopyrenia macrospora* Fink.

Pyrenula megalospora Fink, Minn. Bot. Stud. 2: 329. 1899, not *Arthopyrenia megalospora* Lönner. Flora 41: 634. 1858.

Thallus mainly hypophloeodal, an epiphloeodal film sometimes present and smooth and widely spread over the substratum, ashy in color; apothecia scattered or occasionally occurring in clusters of 2 or 3, black or brownish black, convex with the ostiole-bearing apex somewhat conical, semi-immersed or becoming quite superficial, rather large, 0.4 to 0.75 mm. in diameter, the perithecium dark brown in section, the amphithecium cloudy; paraphyses distinct, slender, simple or branched; asci cylindrical; spores 2-celled, oblong-ellipsoid, somewhat constricted at the septum, 32 to 60 μ long and 14 to 21 μ wide.

Collected at Mankato and at Granite Falls. On trees. Not known elsewhere.

Pyrenula megalospora of the preliminary reports.

2. *Arthopyrenia gemmata* (Ach.) Mass. Ric. Lich. 166. f. 328. 1852.

Lichen gemmatum Ach. Lich. Suec. 17. 1798.

Thallus essentially hypophloeodal, indicated at the surface by a whitish or ashy and frequently widespread coloration, sometimes a very thin epiphloeodal film over all or portions of the surface; apothecia partly immersed, black, smaller than in the last, 0.3 to 0.65 mm. in diameter, the perithecium (or at least the upper half) brownish black or dark brown in section, the amphithecium pale; paraphyses, slender, commonly simple, distinct in ours examined; asci cylindrical; spores ellipsoid, 2-celled, varying considerably in size, ours 12 to 18 μ long and 7 to 9 μ wide, but foreign spores reaching 27 μ long and 12 μ wide.

Collected at Granite Falls and at Thief River Falls. On trees.

Elsewhere in North America in New England, Florida, Ohio, Illinois, Iowa, Quebec, Ontario, and Alaska. Known also in Europe and Africa.

Pyrenula gemmata of the preliminary reports.

3. *Arthopyrenia conoidea* (Fr.) Fink.

Verrucaria conoidea Fr. Lich. Eur. 432. 1831.

Epilithic portion of the thallus rarely present as a whitish and very minutely powdery crust, or the whole thallus apparently wanting or indicated only by an ashy or pale pinkish coloration upon the substratum; apothecia of the same size and appearance as in the last, the perithecium blackish brown in section, the amphithecium pale; paraphyses slender and commonly simple, more or less coherent; asci cylindrical; spores 2-celled, 13 to 20 μ long and 8 to 10 μ wide.

Nylander states as follows: "Vix considerata sit nisi ut status saxicola *gemmatae*," and the two seem certainly to be closely related. However, a careful study of the algal symbionts could not be made in ours, and this might indicate a more remote relationship.

Collected at Bemidji. On limy pebbles.

Not certainly known elsewhere in North America. Found in Europe and Africa.

Verrucaria conoidea of the preliminary reports.

4. *Arthopyrenia quinqueseptata* (Nyl.) Fink.

Verrucaria quinqueseptata Nyl. Mém. Soc. Acad. Maine et Loire 4: 58. 1858.

Thallus hypophloeodal and widely spread in the substratum, indicated at the surface by a whitish coloration, sometimes disappearing; apothecia somewhat larger and more superficial than in the last, globose, the perithecium dark brown in section, the amphithecium pale or light yellowish; paraphyses simple or sometimes branched, more or less gelatinized and coherent, rarely noticeably enlarged and darker toward the apex; asci clavate or cylindrico-clavate; spores linear-oblong, 6 to 8-celled, 16 to 27 μ long and 5 to 8 μ wide.

Includes also the plants reported in the preliminary reports as *Pyrenula hyalospora*, spore characters agreeing with those of the present species.

Collected at Granite Falls, Mankato, and Red Lake. On trees.

Elsewhere in North America in Pennsylvania, South Carolina, Florida, and Iowa. Known also in Asia.

Pyrenula quinqueseptata of the preliminary reports.

5. *Arthopyrenia punctiformis* (Pers.) Mass. Ric. Lich. 168. f. 335. 1852.

Verrucaria punctiformis Pers. Ann. Bot. Usteri 11: 19. 1794.

Thallus hypophloeodal and indicated at the surface by a slight change in color of the substratum, usually to lighter color, but frequently disappearing; apothecia also for most part hypophloeodal, depressed, rounded or oblong, minute or small, 0.1 to 0.9 mm. broad (the latter the long dimension in oblong forms), the perithecium well developed in the upper portion, there dark brown, the amphithecium pale; paraphyses slender, distinct and commonly simple; asci cylindrical or cylindrico-clavate; spores oblong-ellipsoid, 2 to 4-celled, 18 to 24 μ long and 5 to 7 μ wide.

Generally distributed in the State. On trees.

Elsewhere in North America in New England, the Southern States, Illinois, Iowa, Nebraska, Missouri, and California. Known also in Europe, Asia, Africa, and New Zealand.

Pyrenula punctiformis of the preliminary reports.

5a. *Arthopyrenia punctiformis fallax* (Nyl.) Fink.

Verrucaria epidermidis fallax Nyl. Mém. Soc. Acad. Maine et Loire 4: 59. 1858.

Differs in that the paraphyses are scarcely so distinct and the spores frequently become obscurely muriform; apothecia rather smaller and more superficial.

Throughout the northern portion of the State. Commonly on birches.

Elsewhere in North America in Florida and California.

The above is essentially Tuckerman's disposition of the species and the subspecies. Perhaps all of the 4-celled forms should be referred to *Arthopyrenia cerasi* (Schrad.) Hepp, but this disposition has seemed scarcely better.

Pyrenula punctiformis fallax of the preliminary reports.

PYRENULA Ach. Lich. Univ. 64, 314. pl. 5. f. 1-5. 1810.

The thallus is crustose and hypophloeodal, or rarely in part epiphloeodal, and it not infrequently disappears or becomes so nearly wanting that the best sections fail to bring out any evidence of either algal or fungal portions, above or within the substratum. When the epiphloeodal portion is present, it is very thin and smooth or faintly scurfy. In color the thallus is whitish, ashy, or slightly yellowish, and it is commonly widely and irregularly spread over the substratum, being recognizable merely as an area of somewhat different color. The algal symbiont is a form of *Chroolepus*. When the thallus is absent or only to be made out by the most careful microscopic examination the species are, like those of *Arthopyrenia*, frequently placed among certain closely related fungi.

The apothecia are black in all of ours, more or less immersed in the substratum, and of the same general form, size, and structure as those of *Arthopyrenia*. The paraphyses differ from those of the *Arthopyrenias* in that they show less of the tendency toward gelatinized and coherent-indistinct conditions. The spores are brown, and the number of cells varies from 2 to several. They vary in form from oblong to ellipsoid.

The relationship between the present genus and *Verrucaria* has been stated under the latter genus, and the difference in substratum plays no part in the separation of the two genera, except that it is doubtless largely responsible for the difference in structure, which is perhaps after all not sufficient to warrant the separation.

Six species and subspecies occur in the State. On trees.

Type species *Pyrenula verrucosa* Ach. loc. cit. But this plant is a *Verrucaria*, therefore the generic name *Pyrenula* is invalid.

KEY TO THE SPECIES.

Spores 2-celled.

Apothecia usually depressed, completely immersed and indicated at the surface by rounded or oblong black spots.

Apothecia always depressed and completely immersed; spores 12 to 18 μ long..... 4. *P. thelena*.

Apothecia not always depressed and completely immersed; spores 10 to 18 μ long..... 1. *P. cinerella*.

Apothecia partly immersed; spores 14 to 23 μ long..... 2. *P. nitida*

Spores more than 2-celled.

Spores 4 to 8-celled, 14 to 30 μ long..... 3a. *P. leucoplaca pluriloculata*.

Spores never more than 4-celled.

Spores 3 to 4-celled, 10 to 18 μ long; apothecia minute or small, often depressed..... 1a. *P. cinerella quadriloculata*.

Spores 4-celled, 14 to 24 μ long; apothecia globose or depressed-globose, minute..... 3. *P. leucoplaca*.

1. *Pyrenula cinerella* (Flot.) Fink.

Verrucaria cinerella Flot. in Zwackh, Exsicc. no. 217. 1863.

Thallus hypophloeodal and widely-spread when occurring on birch, but frequently on other barks, there more conspicuous, ashy; apothecia completely or partly immersed, minute, 0.1 to 0.3 mm. in diameter, or on birch often showing the oblong form, not always depressed, the perithecium dark brown in section and sometimes complete, the amphithecium pale or yellowish; paraphyses distinct, simple or branched and sometimes slightly enlarged and colored toward the apex; asci clavate or cylindrico-clavate; spores 2-celled, oblong-ellipsoid, 10 to 18 μ long and 5 to 9 μ wide.

Throughout the northern portion of the State. On trees.

Elsewhere in North America in Florida, Iowa, Nebraska, and Ontario. Known also in Europe and South America.

1a. *Pyrenula cinerella quadriloculata* Fink, Minn. Bot. Stud. 2: 276. 1899.

Thallus as above; spores perhaps smaller, passing from 2 to 3 and 4-celled conditions; apothecia also minute or small.

A. Zahlbruckner regards the subspecies to be *Polyblastia fallaciosa* Arn.^a

Common in the northern portion of the State, and once collected as far south as Mankato. On birch. The plant reported from Mankato as *Pyrenula glabrata* does not show the spore characters distinctly in the herbarium specimen and is quite likely to prove to be a form of the present species.

Not known elsewhere, unless Arnold's plant is the same.

2. *Pyrenula nitida* (Weig.) Ach. Ges. Naturf. Freund. Mag. 6: 211. 1812.

Sphaeria nitida Weig. Observ. Bot. 4: 45. 1772.

FIGURE 17.

Thallus hypophloeodal, but always apparent at the surface and showing an ashy and often more or less shining surface, smooth and often varying toward olivaceous, forming more or less rounded areas upon the substratum or more widely spread and irregular; apothecia semi-immersed, middle-sized, 0.2 to 0.6 mm. in diameter, globose, scattered or in clusters of two or three, the perithecium brownish black in

^a Flora 604. 1858.

section, the amphithecium pale or finally darkening; paraphyses distinct and rarely branched; asci cylindrico-clavate; spores 4-celled, ellipsoid, 14 to 23 μ long and 6 to 9 μ wide.

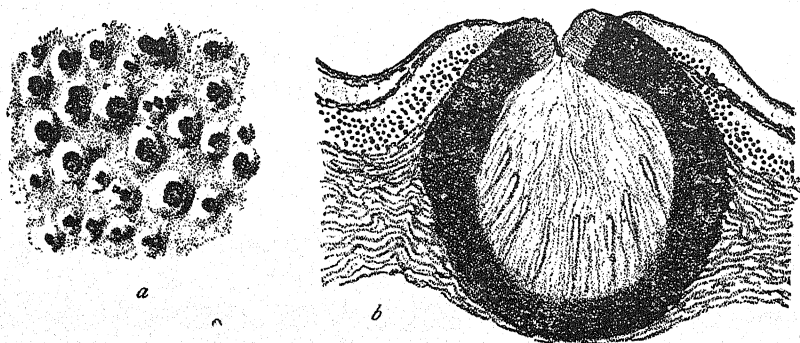


Fig. 17.—*Pyrenula nitida*. a, Portion of thallus with several immersed apothecia; b, section through thallus and an inclosed apothecium to show especially the well developed perithecium and the ostiole. a, Enlarged 3 diameters; b, 50 diameters. From Reinke.

Collected at Minneapolis, Mankato, and New Ulm. On trees, especially oaks.

Distributed throughout the United States and found also in Ontario and British Columbia. Known in all the grand divisions.

3. *Pyrenula leucoplaca* (Wallr.) Koerb. Syst. Lich. 361. 1855. PLATE 49, B.
Verrucaria leucoplaca Wallr. in Bluff & Fing. Comp. Fl. Germ. 3: 299. 1831.

Thallus mainly hypophloeodal, but a thin whitish smooth or finely powdery layer sometimes appearing upon the substratum, and even when wholly hypophloeodal plainly indicated as a whitish coloration, often widely spread, rarely disappearing; apothecia minute, 0.15 to 0.4 mm. in diameter, immersed or becoming more or less superficial, globose or depressed-globose, the perithecium brownish black in section, the amphithecium pale or pale yellowish; paraphyses slender, simple or rarely branched; asci cylindrico-clavate; spores ellipsoid or ellipsoid-pointed, commonly 4-celled, 14 to 24 μ long and 5 to 9 μ wide.

Generally distributed over the State. On trees.

Elsewhere in North America in New England, New York, Illinois, Iowa, Quebec, and Ontario. Known also in Europe.

EXPLANATION OF PLATE 49.—See page 235.

3a. *Pyrenula leucoplaca pluriloculata* Fink, Minn. Bot. Stud. 2: 709. 1901.

Similar except that the spores are rather longer and from 4 to 8-celled.

Common in northwestern Minnesota. On trees, usually other than poplars, on which the common form of the species ordinarily occurs.

Not reported elsewhere, but Tuckerman and Koerber both mention 7-celled conditions, probably the same, and, if so, occurring at least in New England and in Germany.

4. *Pyrenula thelena* (Ach.) Tuck. Gen. Lich. 272. 1872.

Verrucaria thelena Ach. Syn. Lich. 92. 1814.

Thallus hypophloeodal and frequently disappearing, or indicated at the surface of the substratum by a whitish or yellowish coloration; apothecia immersed and depressed, each one indicated by a minute oblong or circular, black spot, the perithecium well developed in the upper hemisphere, there blackish brown in section,

the amphithecium pale; paraphyses but rarely distinct, slender, sometimes branched at the frequently more or less enlarged and colored apex; asci cylindrico-clavate; spores 2-celled, oblong-ellipsoid, 12 to 18 μ long and 5 to 7 μ wide.

The spore measurements given are little more than half as large as those of Nylander;^a yet ours seems to be the view of Tuckerman, who states that the spores are smaller than in *Pyrenula punctiformis*.^b

Collected at Minneapolis, at Mankato, and at Beaudette. These widely separate localities would seem to indicate that the plant is generally distributed over the State. On birch bark, and easily mistaken for other *Pyrenulas* or *Sagedia oxyspora*.

Elsewhere in North America in New England, North Carolina, South Carolina, Alabama, Florida, Ohio, Illinois, Iowa, and Missouri. Found also in South America.

Family DERMATOCARPACEAE.

The family rests upon the characters of the genus *Dermatocarpon*, in which we have a foliose or a squamulose-foliose thallus and apothecia completely immersed in the thallus and indicated at the surface only by an ostiole. With the complete immersion, the perithecium has become abortive, and we have scarcely more than a colorless or slightly colored amphithecium surrounding the hymenium. It is upon this difference in thallus structure and the accompanying variation in apothecial development that the separation of the present family from the closely related *Verrucariaceae* must rest. The spores are simple in both genera, thus resembling *Verrucaria*. And in *Dermatocarpon* at least the paraphyses gelatinize with age, reminding one again of *Verrucaria*.

The present family is closely related to the next as shown in the very similar apothecial development in both *Endocarpon* and *Dermatocarpon*, the amphithecium partly or wholly replacing the usually stronger perithecium.

Thelocarpon is certainly aberrant and is placed here provisionally.

THELOCARPON ^c Nyl. Mém. Soc. Sci. Nat. Cherb. 2: 15, 338. 1854.

The thallus is crustose and verrucose, sometimes spread over the substratum as a thin, continuous or broken layer, but oftener entirely disappearing except the hemispherical nodular veil covering the apothecia. There is no suggestion of any differentiation into layers, and the algal symbiont is a form of *Cystococcus* or *Pleurococcus*. In color the thallus varies from whitish to greenish.

The apothecia resemble those of *Endocarpon* and *Dermatocarpon* in that they are inclosed in the rudimentary exciple (perithecium), except for the pore or ostiole, and in that the amphithecium is present. Also there is a resemblance in that the apothecia are immersed in the thallus, which is often reduced to the thalloid veil surrounding them. The whole inner apothecium, including spores, paraphyses, asci, and amphithecium, is pale. Nylander includes in his genus forms having 8 spores in each ascus and also others having polysporous asci,^d though he originally described the genus as polysporous. The spores are simple and hyaline, or in some species partly 2-celled.

The relationship of the genus is by no means plain and we can perhaps do no better than to allow it to remain where its author placed it, near *Dermatocarpon*.

A single species has been found in the State. On old pine boards and posts and rarely on rocks.

Type species *Thelocarpon albidum* Nyl. loc. cit.

^a Nyl. Mém. Soc. Acad. Maine et Loire 4: 60. 1858.

^b Tuck. Gen. Lich. 272. 1872.

^c The original spelling is followed here and in the next genus.

^d Nyl. Mém. Soc. Acad. Maine et Loire 4: 9. 1858.

1. *Thelocarpon prasinellum* Nyl. Flora 64: 451. 1881.

Thallus a thin crust over the substratum, greenish in color and commonly disappearing, all but the greenish hemispherical veils surrounding and concealing the minute and scattered apothecia; apothecia with thalloid veil scarcely exceeding 0.1 to 0.2 mm. in diameter, and scarcely noticeable except when brightened after rain, the amphitheciium pale; paraphyses slender and considerably branched, and without apical thickening or color; asci cylindrical, ellipsoid, or becoming distended and variously irregular; spores oblong-ellipsoid, numerous in the asci, 4 to 7 μ long and 2.5 to 4 μ wide.

Generally distributed over the State. On old pine wood and rarely on rocks. Easily passed over for *Pleurococcus*, or for *Acolium* in a rudimentary condition, but the hand lens reveals the deception.

Known elsewhere in North America in New Bedford, Massachusetts, and in a number of localities in Iowa. No doubt a common lichen, at least throughout a large portion of North America, but overlooked. Known also in Europe.

DERMATOCARPON Fr. Syst. Orb. Veg. 259. 1825.

The thallus is for the most part plainly foliose with the lobes rising more or less from the substratum, but in some of the smaller species the thallus is smaller and the whole structure closely adnate as in *Endocarpon*. It is thick and rigid and in the higher and more plainly foliose species is attached by an umbilicus, these larger thalli reminding one of forms of *Umbilicaria*. Upper and lower cortices are present, and in the larger species the lower cortex is better developed for support, here again recalling *Umbilicaria*. Within the upper and lower cortices are well developed algal and medullary layers. The algal symbiont is similar to that of *Endocarpon*, but is somewhat larger. In color the thalli vary from ashy and gray to brownish or even a dark brown.

The apothecia are immersed in the thallus and are indicated at the upper surface by numerous minute pores, which appear as spots upon the surface. As in *Endocarpon*, the peritheciium is scarcely developed, and the amphitheciium is usually pale in section. The paraphyses gelatinize with age and become coherent. The spores are simple.

As to spore characters, *Dermatocarpon* is more closely related to *Verrucaria*, but the thallus structure is more like that of *Endocarpon*, this last genus in this respect being intermediate between the other two.

Five species and subspecies have been found within the State. On rocks, trees and earth.

Type species *Dermatocarpon miniatum* (L.) Fr. loc. cit.

KEY TO THE SPECIES.

Never on rocks; small plants, closely adnate.

On trees, margin sometimes slightly raised..... 2. *D. arboreum*.

On earth, margin not raised..... 3. *D. hepaticum*.

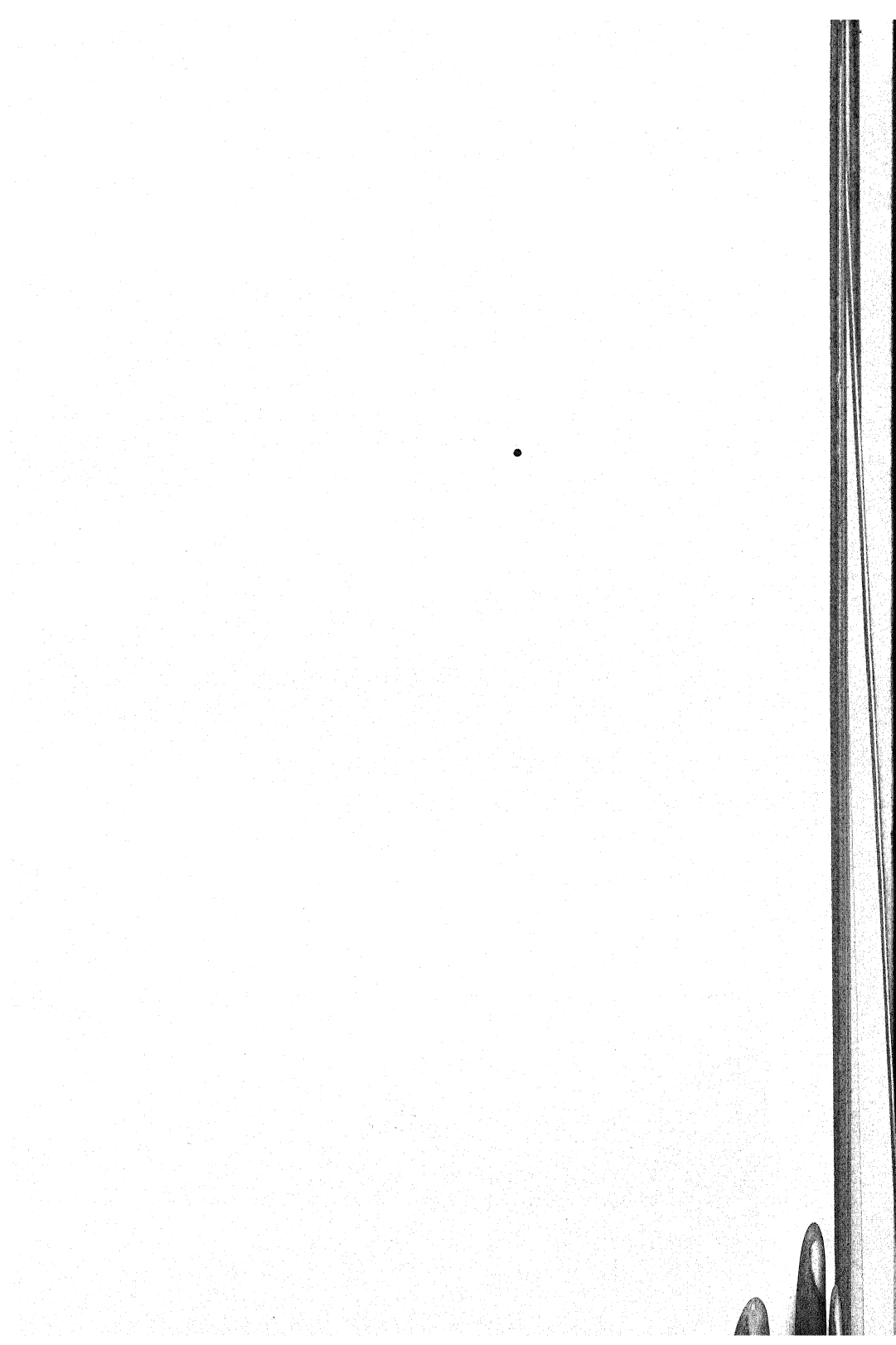
On rocks; larger plants, loosely attached by an umbilicus.

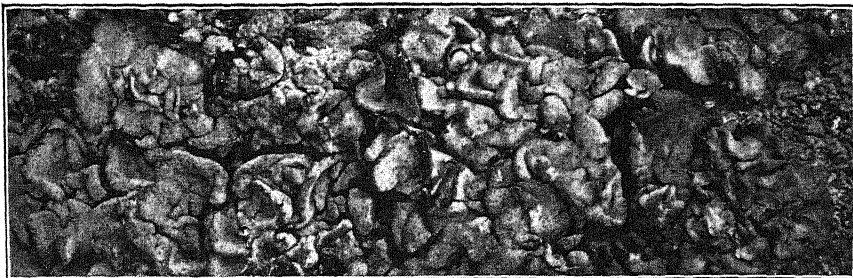
Thallus large, entire or somewhat lobed, ashy to olive-brown..... 1. *D. miniatum*.

Thallus deeply divided into smaller lobes.

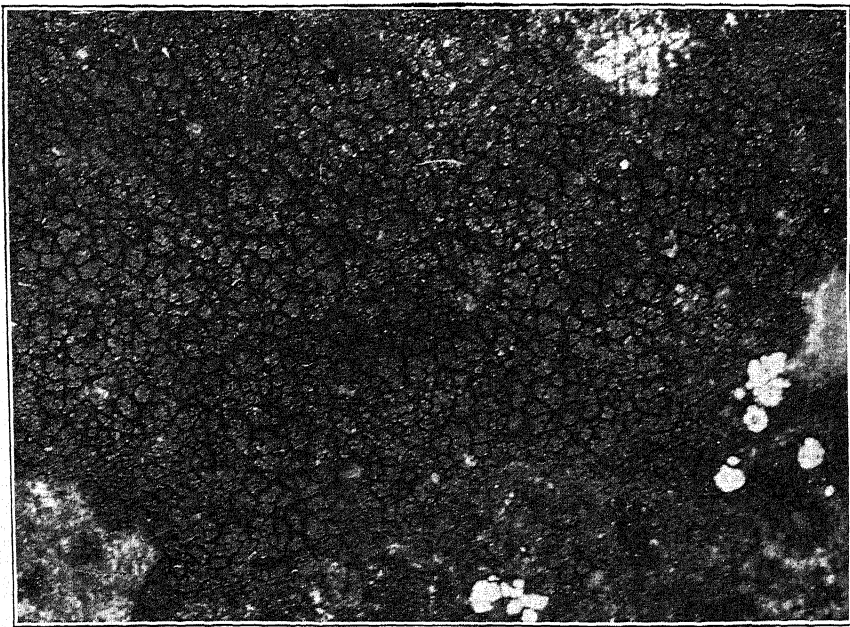
Lobes extending almost to the umbilicus, closely imbricated, of same color as the above..... 1a. *D. miniatum complicatum*.

Lobes less imbricated, thinner, darker-colored; on rocks frequently wet..... 1b. *D. miniatum aquaticum*.





A. *DERMATOCARPON MINIATUM AQUATICUM* (WEIS.) FINK.



B. *STAUROTHELE UMBRINA CLOPIMA* (WAHL.) TUCK.

1. *Dermatocarpon miniatum* (L.) Fr. Syst. Orb. Veg. 259. 1825. FIGURE 18.
Lichen minutus L. Sp. Pl. 1149. 1753.

Thallus loosely attached by an umbilicus, more or less orbicular in outline, the margin entire or somewhat torn or lobed, large, 10 to 60 mm. in diameter, more or less wrinkled, above ashy or varying toward olivaceous-brown, beneath darker varying from a pale olivaceous-brown to a blackish brown and usually finely reticulated,

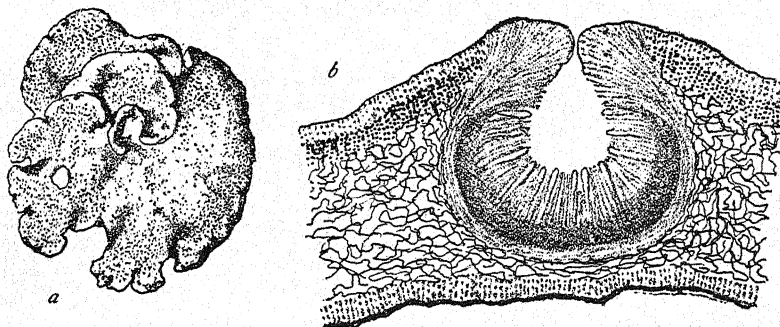


FIG. 18.—*Dermatocarpon miniatum*. a, Plant with the ostioles showing as black dots; b, section through the thallus showing an apothecium having an amphothecium; a, Natural size; b, enlarged 75 diameters. From Reinke.

especially toward the margins; apothecia indicated by the pores or ostioles, which appear upon somewhat raised and darker, minute spots, the amphothecium pale, or rarely pale brownish; paraphyses soon gelatinized and coherent, indistinct; asci irregularly clavate, or cylindrico-clavate; spores ellipsoid, hyaline or very faintly colored, 9 to 16 μ long and 5 to 8 μ wide.

Generally distributed over the State. On rocks, especially calcareous.

Also widely distributed in North America. Found also in Europe and Africa.

Endocarpon miniatum of the preliminary reports.

- 1a. *Dermatocarpon miniatum complicatum* (Lightf.) Th. Fr. Nov. Act. Soc. Sci. Ups. III. 3: 353. 1861.

Lichen minutus complicatus Lightf. Fl. Scot. ed. 2. 858. 1777.

Thallus deeply divided, the divisions often extending almost to the umbilicus, the lobes becoming much imbricated (complicate) and sometimes severed from the umbilicus, this giving rise to the falsely polyphyllous state. More raised from the substratum and scarcely so widely spreading.

Distributed in the State as the species, and more common. On rocks frequently wet.

North American distribution also quite as general as that of the species. Found also in Europe and Africa.

Endocarpon miniatum complicatum of the preliminary reports.

- 1b. *Dermatocarpon miniatum aquaticum* (Weiss) Fink. PLATE 50, A.
Lichen aquaticus Weiss, Pl. Crypt. Gott. 77. 1770, not L. 1753.

Thallus quite similar to that of the last, but rather thinner and less imbricated, more inclined to a brownish color above and blackish below.

Reported in the preliminary reports from all parts of northern Minnesota and studied under the synonym *Endocarpon fluviatile*. Doubtless the present form is as widely distributed in the State, but is frequently overlooked in the beds of streams where it occurs on the rocks. Hardly entitled to the specific rank now commonly given the plant, and herbarium specimens indicate that, in North America at least, it is quite generally confused with the last.

Elsewhere in North America reported in New England, British America, New Jersey, North Carolina, Alabama, and Ohio. Also known in Europe and New Zealand.

Endocarpon miniatum aquaticum of the preliminary reports.

EXPLANATION OF PLATE 50.—A, Plant of *Dermatocarpon miniatum aquaticum* on rock, showing the thickened and irregularly imbricated thallus. B, Plant of *Staurothele umbrina clopima* on rocks, showing the areolate thallus and a few apothecia. A, about one-third natural size; B, enlarged 3 diameters.

2. *Dermatocarpon arboreum* (Fr.) Fink.

Endocarpon arboreum Fr. Lich. Eur. 407. 1831.

Thallus closely adnate or the margins slightly raised, squamulose-foliose, the squamules 2 to 10 mm. in diameter, scattered upon the substratum or more commonly clustered and more or less imbricated, the margins entire and rounded or more or less lobed, pale olivaceous or brownish above, below pale with darkening rhizoids; apothecia indicated by the pores, these seen as brown or reddish brown spots upon the thallus, the amphithecium pale; paraphyses soon becoming gelatinized and coherent-indistinct; asci cylindrical or cylindrico-clavate; spores hyaline, ellipsoid, 10 to 15 μ long and 4 to 6 μ wide.

Collected twice in the State, at Redwood Falls and at Rainy Lake City. On trees.

A North American lichen known elsewhere at New Bedford, Massachusetts, and in Florida, Alabama, South Carolina, Texas, Ohio, Illinois, and Iowa.

Endocarpon arboreum of the preliminary reports.

3. *Dermatocarpon hepaticum* (Ach.) Th. Fr. Nov. Act. Soc. Sci. Ups. III. 3: 355. 1861.

Endocarpon hepaticum Ach. Lich. Univ. 298. 1810.

Thallus closely adnate, squamulose, the squamules rounded or irregular in form, small, 1 to 4 mm. across, reddish brown or olivaceous in color, more commonly closely clustered upon the substratum and sometimes more or less imbricated, below densely covered with hyphal rhizoids; apothecia indicated by the pores, these indistinctly seen as minute, darker spots, the amphithecium pale; paraphyses becoming gelatinized and indistinct; asci cylindrico-clavate or cylindrical; spores hyaline, ellipsoid, 9 to 12 μ long and 5 to 7 μ wide.

Widely distributed over the State. On bare earth and easily overlooked.

Generally distributed throughout North America. Also in all of the grand divisions except South America.

Endocarpon hepaticum of the preliminary reports.

Family ENDOCARPACEAE.

The family is closely related to the Dermatocarpaceae through *Endocarpon* and perhaps only less closely with the Verrucariaceae through the other genus of the family, *Staurothele*. In *Endocarpon* we have the same apothecial structure as in *Dermatocarpon*, but very different spores. And the thallus structure in the two genera also shows a somewhat close relationship. In *Staurothele* we find a typically crustose thallus quite similar to that of *Verrucaria*; but better developed. Also the perithecium is well developed. However, the spores are of the muriform type, resembling very closely those of *Endocarpon*, and it is on account of this resemblance in spore characters that we have placed *Staurothele* with the present family rather than with the Verrucariaceae.

The family is represented in our flora by the two genera and only a few forms.

ENDOCARPON^a Hedw. Descr. Musc. Frond. 2: 56. pl. 20. f. a. 1789.

The thallus is small and apparently crustose, but in section it shows rather the characters of a foliose thallus, having the algal, medullary, and upper cortical layers

^a The original spelling is followed.

well developed. The structure is composed of minute rounded or more or less irregular squamules, which may be scattered and solitary upon the substratum, or more or less clustered. The thallus is closely attached to the substratum by rhizoids. The color usually resembles that of dirt, so that it is easily passed over. The algal symbiont is somewhat different from the common *Cystococcus* and seems to be *Pleurococcus*.

The apothecia are immersed in the thallus, usually one in each squamule, and are minute and indicated at the surface only by an irregular and obscure pore. The perithecium is scarcely developed, but the amphithecium is pale or more commonly becomes brown or brownish. The paraphyses are distinct while young and short, but soon become gelatinized and coherent with each other and with the likewise gelatinized asci, so that the whole hymenial mass is involved. The spores are muriform, hyaline or brown, commonly fewer than eight in each ascus. Thelial algae, or algae within the apothecium, are a peculiarity of the genus.

The present genus is closely related to *Dermatocarpon*, as apparent in the general resemblance of the apothecia and their disposition, in the similarity in the algal symbionts, and only less in the considerable similarity in the gallus structure. Also there is a close relationship with *Verrucaria*, shown in the apothecial characters and in the nature of the algal symbiont, though there is some doubt regarding the algal symbiont of the latter. The close relationship to *Staurothele* is shown in the spores.

A single species is found in the State. On rocks.

Type species *Endocarpon pusillum* Hedw. loc. cit.

KEY TO THE SPECIES.

On calcareous rocks, thallus quite thick..... 1. *E. pusillum*.

On earth, thallus thinner and lighter-colored 1a. *E. pusillum*
garovaglii.

1. *Endocarpon pusillum* Hedw. Descr. Musc. Frond. 2: 56. pl. 21. f. a. 1789.

Thallus foliose-squamulose, closely adnate, the squamules scattered or clustered, minute, 0.2 to 1.5 mm. across, sometimes in the closely clustered conditions forming an areolate surface or becoming more or less imbricated; the smaller ones rounded but the larger variously irregular, rather thick, appearing dirty to the unaided eye, but usually more or less olivaceous-brown under the lens; apothecia minute, one to four or rarely more in each squamule, immersed and their position indicated by the pore, this occupying a somewhat raised spot, the perithecium scarcely developed, the amphithecium pale or turning brownish; paraphyses becoming coherent and indistinct; asci clavate; spores brownish or at first hyaline, muriform, oblong, commonly 2 in each ascus, 23 to 45 μ long and 12 to 18 μ wide.

On calcareous rocks, especially surface pebbles, and found in the State wherever such pebbles occur. Collected in several places in southwestern Minnesota, at Minneapolis, and in the Leaf Hills.

Known throughout the United States east of the Rocky Mountains. Found also in Europe.

1a. *Endocarpon pusillum garovaglii* (Mont.) Fink.

Verrucaria garovaglii Mont. Ann. Sci. Nat. Bot. III. 2: 59. 1849.

Thallus thinner and lighter-colored, the squamules on the whole smaller, though the smallest ones are very obscure and difficult to see upon the earthy substratum.

Same general distribution in the State as the last, but also collected at Tower. On earth, and possibly rarely on rocks.

Elsewhere in North America at New Bedford, Massachusetts, and in Illinois and Iowa. Known also in Europe and Africa.

STAUROTHELE Norm. Nyt. Mag. Naturv. 7: 240, 252. pl. 2. f. 23. b, c. 1853.

The thallus is crustose and usually devoid of distinct differentiation into layers, but sometimes shows a poorly developed cellular cortex. It is usually quite thick and evident upon the substratum, on the whole rather more so than in the closely related *Verrucarias*, and is verrucose or rarely distinctly areolate. In some of the species it is small and more or less orbicular and in others it is widely spread over the substratum. The color varies from ashy to dark brown. The nature of the algal symbiont is somewhat uncertain, being either *Pleurococcus* or *Chroolepus*.

The apothecia are small or minute and entirely or almost completely immersed in the thallus, being indicated at the surface either by dark spots with the ostiole at the center of each, or merely by the ostiole. The perithecium is well developed and dark in color, dark or blackish brown in section and darker macroscopically. Within this is the amphithecium, usually pale. The paraphyses are commonly gelatinized and coherent. The spores are muriform and commonly brown or brownish, though hyaline spores occur within the genus.

The present genus seems closely related to *Verrucaria*, except for the spores, which are very different. Indeed, the genera are frequently united by lichenists, but evidently without propriety. The spores suggest a closer relationship with *Endocarpon*.

Three species and subspecies occur in the State. On rocks.

Type species *Staurothele megalospora*, Norm. loc. cit.

KEY TO THE SPECIES.

- Spores eight in each ascus. 2. *S. diffractella*.
 Spores two in each ascus.
 Thallus thin, smooth or granulose, ashy-olivaceous or brownish. 1. *S. umbrina*.
 Thallus much thicker, roughened, verrucose or areolate, chestnut-brown or darker. 1a. *S. umbrina clopima*.

1. *Staurothele umbrina* (Ach.) Tuck. Gen. Lich. 258. 1872.

Lichen umbrinus Ach. Lich. Suec. 14. 1798.

Thallus rather thin, smooth or becoming granulose, chinky or even subareolate, widely and irregularly spread over the substratum as a continuous or more or less broken layer, ashy-olivaceous to brownish in color; apothecia minute, immersed in the thallus and indicated by the ostiole or pore, the perithecium brownish-black, the amphithecium pale; paraphyses gelatinized and coherent; asci clavate or variously irregular; spores brown, muriformly many-celled, oblong, 2 in each ascus, 30 to 48 μ long and 12 to 18 μ wide.

Collected in the Misquah Hills, about Snowbank Lake, at Mankato, and at Granite Falls. On various rocks.

Elsewhere in North America in New England, Wisconsin, Iowa, and Nebraska. Known also in Europe, Asia, and New Zealand.

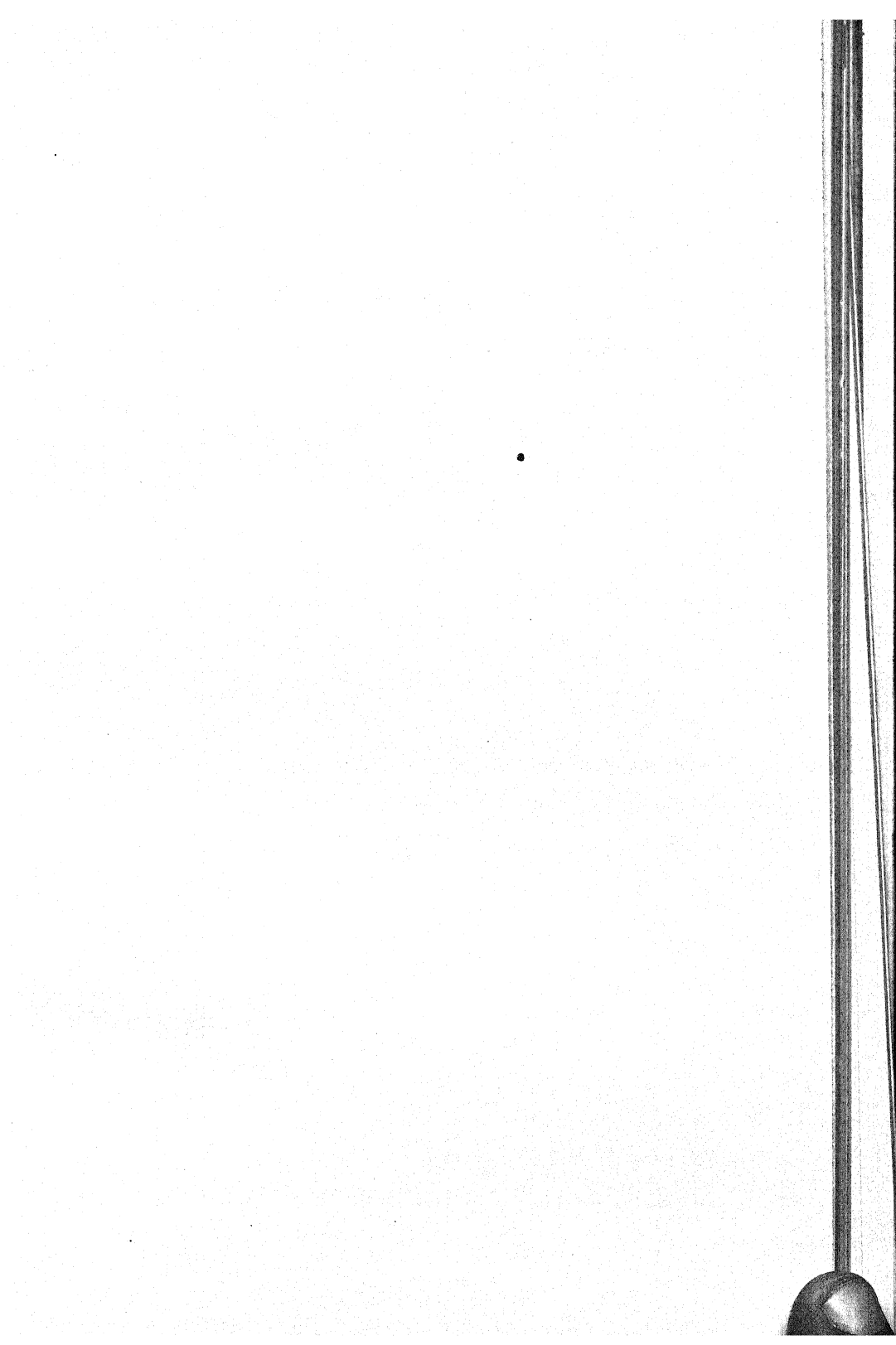
1a. *Staurothele umbrina clopima* (Wahl.) Tuck. Gen. Lich. 258. 1872.

Verrucaria clopima Wahl. in Ach. Meth. Lich. Suppl. 19. 1803. PLATE 50, B.

Thallus much thickened, roughened-verrucose or becoming areolate, chestnut-brown or darker; apothecia often deeply immersed and the ostiole depressed.

Widely distributed over the State, but probably not occurring in the southeastern portion. On rocks other than calcareous.

Elsewhere in North America in the White Mountains (New Hampshire). Known also from Europe and Africa.





AMPHILOMA LANUGINOSUM (HOFFM.) NYL.

2. Staurothele diffractella (Nyl.) Tuck. Gen. Lich. 258. 1872.*Verrucaria diffractella* Nyl. Mém. Soc. Acad. Maine et Loire. 4: 33. 1858.

Thallus ashy, varying toward pale yellowish or olivaceous-brown, chinky-areolate (diffract), widely spread over the substratum as a continuous or more or less broken crust; apothecia immersed in protuberant areoles of the thallus, minute and indicated by the ostiole and surrounding minute darkened area, the perithecium dark brown or blackish brown, the amphithecium pale; paraphyses becoming gelatinized and coherent; asci clavate or variously irregular; spores ellipsoid, hyaline, muriform, but cells far less numerous than in the last, sometimes slightly colored, 15 to 22 μ long and 9 to 12 μ wide, eight in each ascus.

Whole external appearance much as in the species above.

Collected at New Ulm and Granite Falls. On various rocks.

A North American lichen known elsewhere in Vermont, Massachusetts, Alabama, Illinois, Iowa, and Missouri.

Family LEPRARIACEAE.**AMPHILOMA** Fr.; Koerb. Syst. Lich. 110. 1855.

The thallus is very rudimentary, consisting of a tangled mass of fungal hyphæ, which are closely mingled with the algal cells. It is evidently devoid of cortical layers and not differentiated internally into medullary and algal layers. The whole structure is soredioid in nature and appears as a whitish, mealy or at least friable growth, confined to moist habitats. Clustered, downward-extending, dark bundles of hyphæ form the rhizoids. The algæ are at least closely related to *Cystococcus humicola*. The existence of apothecia is to be doubted.

Our only species has been placed with the genus *Pannaria*, without any apparent reason. While there is certainly a lichen in the making, not enough is known of the fungal symbiont to warrant any definite statement as to relationship. Our common *Pleurococcus vulgaris* of trees and rocks in moist places is almost always associated with fungal hyphæ, and the closely associated algæ and fungi may spread about over the substratum and appear quite like a rudimentary lichen thallus. This association is nearer to the present lichen genus than any other structure known to the writer.

A single species occurs on our trees or rocks or rarely on earth in moist places.

Type species *Amphiloma elegans* (Link.) Fr. loc. cit. But this our *Placidium elegans*, and the genus *Amphiloma*, is invalid and must be abandoned in the revision of lichen genera.

Amphiloma lanuginosum (Hoffm.) Nyl. Act. Soc. Linn. Bord. 21: 215. 1856.

PLATE 51.

Lichen lanuginosus Hoffm. Enum. Lich. Icon. 172. 1784.

Thallus closely adnate, granulose; orbicular and with plain lobation at the circumference or widely spread over the substratum and irregular in form and without lobing, when orbicular about 25 to 65 mm. in diameter, sea-green varying toward whitish or very rarely toward a pale sulphur-color, said to have a thin blue-black hypothallus; apothecia hardly known.

Widely distributed in the State. On rocks and bases of trees, rarely on earth in moist places.

Common enough in the United States east of the Rocky Mountains and northward throughout eastern British America and also in Alaska. Known in all of the grand divisions.

Pannaria lanuginosa of the preliminary reports.

EXPLANATION OF PLATE 51.—Plant, scattered where exposed, but forming a continuous crust where shaded by a fallen log. About one-sixteenth natural size.

GLOSSARY.

- Acicular.* Slender or needle-shaped, as the spores in *Bacidia*.
- Adnate.* As applied to the apothecium, attached to the thallus or substratum by the whole lower side. (Fig. 16, p. 232.)
- Amphithecium.* A layer of tissue continuing upward from the hypothecium in some angiocarpic lichens and nearly surrounding the hymenium. (Fig. 18, p. 243.)
- Angiocarpic.* Having the hymenium inclosed by a perithecium, by an amphithecium, or by both structures. (Fig. 17, p. 239.)
- Apothecium.* The spore-bearing organ, consisting of the hymenium, the epithecium, the hypothecium, and the exciple or exciples.
- Areole.* A small polygonal area of a lichen thallus, separated from other similar areas by a minute chink. (Pl. 8, B, facing p. 100.)
- Ascogenous.* Ascus-producing.
- Ascus.* A specialized hyphal cell in which the spores are produced. (Pl. 3, facing p. 63.)
- Autonomy.* An individual.
- Biatoroid.* Resembling the *Lecideas* of the section *Biatora*: used specifically of apothecial structure.
- Cephalodium.* A small, regular or irregular growth appearing on the surface of a few lichen thalli, containing algal cells and fungal hyphæ, usually inclosed finally in cellular cortex. (Pl. 29, facing p. 159.)
- Cilium.* A slender filament, composed of a bundle of hyphæ, occurring on the upper surface or along the margin of the thallus.
- Cortex.* Pseudoparenchyma forming upper and lower protective layers in many lichen thalli. (Fig. 12, p. 156.)
- Crustose.* As applied to some lichen thalli, crust-like, or closely attached to the substratum and without distinct cortex. (Pl. 49, B, facing p. 235.)
- Cyphella.* A minute depression in the under surface of certain lichen thalli. (Pl. 26, facing p. 154.)
- Dermis.* In some lichens a distinctly marked layer above the upper cortex consisting of flattened cells. (Pl. 9, facing p. 101.)
- Difform.* Irregular in form, as certain apothecia. (Pl. 2, B, facing p. 54.)
- Ectotrophic.* Lying on the surface of the thallus. (Pl. 29, facing p. 159.)
- Ellipsoid.* In the form of an ellipse, or oblong with much rounded ends.
- Endotrophic.* Within the thallus.
- Epilithic.* Upon rocks.
- Epiphylæodal.* Upon the bark.
- Epithecium.* A structureless thalloid remnant lying upon the hymenium.
- Exciple.* A layer surrounding the hymenium laterally and sometimes produced into a perithecium. (Fig. 14, p. 178.)
- Exosporium.* The outer coat of the spore wall. (Pl. 3, facing p. 63.)
- Farinose.* Covered with a mealiness.
- Flexuose.* Said of exciples or apothecia and meaning that the margin of the apothecium, or the exciple, is not circular, but bent alternately in and out and thus irregular in outline.
- Foliose.* Flat and more or less leaf-like; applied to thalli. (Pl. 28, facing p. 157.)
- Fruticose.* Shrub-like in form; applied to thalli. (Pl. 39, facing p. 203.)
- Gelatinized.* Transformed into a jelly-like mass.

- Granulose*. Composed of small or minute granules; said of a class of thalli. (Pl. 5, A, facing p. 70.)
- Gymnocarpic*. Having an open disk, the exciple not being produced so as to cover the disk. (Fig. 9, p. 62.)
- Haustorium*. An expanded or a branched area of a fungal hypha, entering or closely applied to an algal cell for the purpose of securing nourishment. (Fig. 1, p. 9.)
- Hyaline*. Colorless or transparent.
- Hymenium*. The portion of the apothecium composed of the asci and the paraphyses. (Pl. 11, facing p. 107.)
- Hypha*. One of the septate, cylindrical, and branched elements of the fungal symbiont.
- Hyphal rhizoid*. A hypha which penetrates the substratum and performs the functions of a rhizoid. (Pl. 32, facing p. 170.)
- Hypolithic*. Below the surface of rocks.
- Hypophloeodal*. Below the surface of bark.
- Hypothallus*. A colored layer below or surrounding a few lichen thalli.
- Hypothecium*. The dense hyphal or cellular tissue below the hymenium. (Pl. 18, facing p. 131.)
- Immersed*. Sunken into the thallus or the substratum. (Fig. 18, p. 243.)
- Isidioid*. Coral-like and applied to certain outgrowths upon the surface of some thalli.
- Lecideoid*. Resembling Lecideas of the section Eulecidea: used with special reference to the apothecial structure.
- Leprose*. Scurfy; said of certain thalli.
- Lithophytic*. Rock-inhabiting.
- Medulla*. The network of hyphae in the interior of well-developed thalli. (Pl. 40, facing p. 204.)
- Muriform*. Resembling bricks in a wall; applied to compound spores which do not consist of a single row of cells. (Pl. 21, facing p. 136.)
- Mutualism*. That form of symbiosis in which both symbionts are benefited.
- Nutant*. Nodding.
- Ostiole*. The aperture at the summit of a perithecium, through which the spores escape. (Fig. 15, p. 188.)
- Pale*. Whitish in color, translucent rather than transparent, between hyaline and cloudy.
- Paraphysis*. One of the specialized, simple or more commonly branched hyphae, occurring in the hymenium. (Pl. 3, facing p. 63.)
- Parenchymatous*. Resembling a true parenchyma, as the cellular cortex in many lichens. (Fig. 3, p. 16.)
- Perithecium*. The produced exciple of the angiocarpic lichens, inclosing the hymenium, except at the apical ostiole. (Fig. 17, p. 239.)
- Phyllocladium*. A small, specialized and highly assimilative branch of a fruticose thallus.
- Podetium*. An alga-bearing, branched or unbranched stalk, rising from the primary or horizontal thallus in certain lichens and bearing the apothecia. (Pl. 15, facing p. 114.)
- Polar 2-celled*. Applied to spores that are 2-celled and have the two cells widely separated, situated at the opposite ends of the spore. (Pl. 46, facing p. 218.)
- Proliferation*. Used in describing Cladonias of the production of podetia from the sides or tops of other podetia.
- Proper exciple*. The exciple which is an upward continuation of the hypothecium and devoid of algal cells. (Fig. 11, p. 95.)
- Pruinose*. Covered with a bloom or powdery secretion.

Pseudocortex. A cortex devoid of cellular structure and commonly showing well defined or more or less gelatinized hyphæ. (Pl. 4, facing p. 67.)

Pustule. A pimple-like or blister-like elevation.

Pyrenocarpic. Same as angiocarpic.

Rank. One of several series of podetia, produced successively by proliferations from one or more podetia of the next series below.

Rhizoid. A slender filament, consisting of a bundle of hyphæ, extending downward from the lower side of the thallus and usually penetrating the substratum. (Fig. 12, p. 156.)

Rimose. Having chinks or cracks.

Scyphiform. Cup-like, or forming a cup; said of some podetia. (Pl. 17, facing p. 125.)

Sea-green. The peculiar greenish-gray which is the most common color of lichen thalli.

Sessile. As applied to apothecia, meaning attached to the substratum by the central portion of the lower side. (Pl. 36, A, facing p. 194.)

Solexform. Slipper-shaped; said of certain spores.

Soredium. A tangled mass of algal cells and fungal hyphæ, which is able to grow into a new thallus under favorable circumstances of environment. (Pl. 43, B, facing p. 210.)

Spermagonium. A minute cavity more or less embedded in the thallus and containing the spermatia borne upon sterigmata. (Fig. 4, p. 17.)

Spermatium. One of the spore-like bodies contained in the spermagonia and supposed by some lichenists to be male reproductive bodies. (Fig. 4, p. 17.)

Squamule. One of the small scales which compose certain lichen thalli. (Pl. 15, facing p. 114.)

Squamulose. Composed of squamules.

Stipe. An apothecial stalk, devoid of algal cells. (Pl. 1, A, facing p. 48.)

Symbiont. One of the individuals of a symbiosis.

Symbiosis. A living together of two, or rarely more, dissimilar individuals with mutual benefit, or at least with benefit to one of the symbionts.

Thalloid. Thallus-like.

Thallus. The vegetative portion of any lichen, bearing the reproductive areas or organs.

Thecial. Occurring within the thecium (or hymenium). (Fig. 6, p. 29.)

Trichomatic. Trichome-like.

Tubiform. Trumpet-shaped, said of certain podetia.

Turbinate. Top-shaped.

Umbilicus. The single strong attaching organ of some lichen thalli, composed of a large number of closely united hyphæ.

Uniseriate. Placed in a single row; applied to spore arrangement in the ascus.

Urceolate. Pitcher-shaped, or cup-shaped.

Verruca. A wart-like elevation of a lichen thallus.

Verrucose. Covered with verrucæ.

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By P. L. RICKER.

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The titles under each author's name are arranged chronologically.

The following abbreviations are used to indicate the libraries in which the works have been consulted:

AGR.	United States Department of Agriculture.
ASH.	Prof. A. S. Hitchcock, United States Department of Agriculture.
AMHERST.	Amherst College, Amherst, Mass. (Tuckerman's library.)
FARL.	Dr. W. G. Farlow, Cambridge, Mass.
FINK.	Prof. Bruce Fink, Oxford, Ohio.
GH.	Gray Herbarium, Cambridge, Mass.
GREENE.	Dr. E. L. Greene, United States National Museum.
HC.	Harvard College.
HOLM.	Dr. Theodor Holm, Brookland, D. C.
LC.	Library of Congress.
LLOYD.	The Lloyd Library, Cincinnati, Ohio.
MINN.	University of Minnesota, Minneapolis.
Mo. BG.	Missouri Botanical Garden.
NM.	National Museum.
NYBG.	New York Botanical Garden.
PHIL. ACAD.	Academy of Natural Sciences, Philadelphia.
PSNH.	Portland Society of Natural History, Portland, Me.
SC.	Smithsonian Collection, Library of Congress.
SURG.	Surgeon-General's Library.

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FINK. LLOYD. AGR.

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 Very rare. Not located in the U. S. cf. Bolton, Cat. Sci. Tech. Period. ed. 2. No. 4185. p. 508. 1897.
- Hedl. HEDLUND, T.** Kritische bemerkungen über einige arten der flechtengattungen Lecanora (Ach.), Lecidea (Ach.) und Micarea (Fr.) Bih. Svensk. Vet. Akad. Handl. 18^m 3: 1-104. 1 pl. 1892.
- Hedw. Descr. Musc. Frond.** HEDWIG, JOHANN. Descriptio et adumbratio microscopico-analytica muscorum frondosorum nec non aliorum vegetantium e classe cryptogamica Linnaei novorum dubiisque vexatorum. 4 v. Lipsiae, J. G. Muller, 1787-1797. 40.5 cm. LLOYD. AGR.
 This is often quoted as Stirpium Cryptogamium.
- Hepp, Spor. Flecht. Eur.** HEPP, PHILIPP. Abbildungen und beschreibung der sporen zum i.-xvi. b and der Flechten Europas in getrockneten mikroskopisch untersuchten exemplaren. 4 v. Zürich. Zu beziehen bei dem herausgeber, 1853-1867. 29 cm. AGR.
 v. 1. 4 p. 1. pl. 1-26. 1853; v. 2. 3 p. 1. pl. 27-55. 1857; v. 3. 3 p. 1. pl. 56-82. 1860; v. 4. 1 p. 1. pl. 83-110. 1877.
- Hoffm. Enum. Lich. Icon.** HOFFMANN, GEORG FRANZ. Enumeratio lichenum iconibus et descriptionibus illustrata. 1 p. 1. 102 p. 22 pl. Erlangae, sumtibus Wolfgangi Waltheri, 1784. 26.5 cm. NYBG. AMHERST. LLOYD. GH.

- Hoffm. Descr. Pl. Crypt.** HOFFMANN, GEORG FRANZ. Descriptio et adumbratio plantarum e classe cryptogamica Linnaei quae lichenes dicuntur. 3 v. Lipsiae, Siegfried Lebrecht, 1790-1801. 36.5 cm. AGR.
v. 1. 1 p. 1. iv, 104 p. 1. 1. 24 pl. 1790; v. 2. 2 p. 1. 78 p. 1. 1. 25-48. 1794; v. 3. 2 p. 1. 14, 18, 18, 12 p. 1. 1. pl. 49-72. 1801. Each volume issued in three fascicles the title-page to each volume being with the fourth fascicle of the volume. Perhaps each three preceding fascicles are of earlier dates.
- Hoffm. Deutschl. Fl.** HOFFMANN, GEORG FRANZ. Deutschlands flora oder botanisches taschenbuch. Zweyter theil für das Jahr 1795. Cryptogamie, 28 p. 1. 200 p. 20 1. Erlangen, Johann Jacob Palm, 1795. 14 cm. GREENE. NM.
- Hook. & Tayl.** HOOKER, JOSEPH DALTON, AND TAYLOR, THOMAS. Lichenes Antartici; being characters and brief descriptions of the new lichens discovered in the southern circumpolar regions, Van Diemen's Land and New Zealand, during the voyage of H. M. discovery ships Erebus and Terror. Lond. Journ. Bot. 3: 634-658. 1844.
- Huds. Fl. Angl.** HUDSON, WILLIAM. Flora Anglica, exhibens plantas per regnum Angliae sponte crescentes distributas secundum systema sexuale: cum differentiis speciorum, synonymis autorum, nominibus incolarum, solo locorum, tempore florendi, officinalibus pharmacopaeorum. viii p. 4 l. 506 p. 11 l. Londini: Impensis auctoris: Prostant venales apud J. Nourse in the Strand, A. C. Moren in Covent Garden, 1862. 20.5 cm. LLOYD. AGR.
Ed. 2. Editio altera, emendata et aucta. 28 p. 1. 690 p. London, J. Nourse, 1778. 21.5 cm. AGR.
- Humb. Fl. Friberg.** HUMBOLDT, FREDERIC ALEXANDER. Florae Fribergensis specimen plantas cryptogamicas praesertim subterraneas exhibens. Edidit Fredericus Alexander ab Humboldt. Accedunt aphorismi ex doctrina physiologiae chemicae plantarum. xiv, 190. p. 4 pl. Berolini. Apud Henr. Augustum Rottmann, 1793. 26 cm. LLOYD. Mo. BG.
- Jacq. Coll. Bot.** JACQUIN, NICHOLAUS JOSEPH. Collectanea ad botanicam, chemiam et historiam naturalem spectantia, cum figuris. 5 v. Vindobonnae, ex officina Wappleriana, 1786-1796. 30.5 cm. LLOYD. LC.
v. 1. 386 p. 22 col. pl. 1786; v. 2. 374 p. 18 col. pl. 1788; v. 3. 306 p. 23 col. pl. 1789; v. 4. 359 p. 27 col. pl. 1790; v. 5. Supplementum, 171 p. 16 col. pl. 1796.
- Journ. Bot. Schrad.** Journal für die Botanik. Herausgegeben vom medicinalrath Schrader. 5 v. 1799-1803. AGR. NM.
- Journ. Phys. Chem. Hist. Nat.** Journal de Physique, de Chimie, d'Histoire Naturelle et des Artes, avec des planches en taillédouce. SC.
- Kickx, Fl. Crypt. Fland.** KICKX, JEAN JACQUES. Flore cryptogamique des Flandres. Œuvre posthume de Jean Kickx. 2 v. Gand, H. Hoste etc. etc. 1867. 26 cm. LLOYD. SC.
v. 1. vi p. 1. 1. 521 p.; v. 2. 3 p. 1. 490 p.
- Koerb. Lich. Germ. Spec.** KOERBER, GUSTAV WILHELM. Lichenographiae Germanicae specimen, Parmeliacearum familiam continens. Commentatio botanica, quam consensu et auctoritate amplissimi philosophorum ordinis in universitate literaria Vratislaviensi pro obtinenda legendi venia die xxiii. Maii, anni mdcccxlvi. H. L. Q. C. publice defendet. 2 p. 1. 22 p. Vratislaviae, Typis Grassii, Barthii et Sociorum, 1846. 24.5 cm. LLOYD.
- Koerb. Syst. Lich.** KOERBER, GUSTAV WILHELM. Systema lichenum Germaniae Die flechten Deutschlands (insbesondre Schlesiens) mikroskopisch geprüft, kritisch gesichtet, charakteristisch beschrieben und systematisch geordnet. xxxiv p. 1. 1. 458 p. 4 col. pl. Breslau, Trewendt & Granier, 1855. 22.5 cm. MINN. PINN. LLOYD. AGR.

- Koerb. Par. Lich.** KOERBER, GUSTAV WILHELM. *Parerga lichenologica*. Ergänzungen zum Systema lichenum Germaniae. xvi p. 1 l. 501 p. Breslau, Eduard Trewendt, 1865. 22 cm. MINN. FINK. AGR.
- Krempelh.** KREMPELHUBER, AUGUST VON. Ueber *Lecidea prevostii* Schaer. *Flora* 35: 17-26. pl. 1. f. 1-7. 1852.
- Krempelhuber,** AUGUST VON. Geschichte und litteratur der lichenologie von den ältesten zeiten bis zum schlusse des jahres 1865. 3 v. München, C. Wolf & Sohn, 1867-72. FINK. AGR.
v. 1. Front. xi p. 2 l. 616 p. 1867; v. 2 Front. vi p. 1 l. 776 p. 1869; v. 3. Die fortschritte und die litteratur der lichenologie in dem zeitraume von 1866-1870 incl. nebst nachträgen zu den früheren perioden. xlii p. 1 l. 260 p. 1 l. 1872. 23 cm.
- Lam. & DC. Fl. Fr.** See LA MARCK, J. B., AND DE CANDOLLE, A. P.
- Lamy de LA CHAPELLE,** EDOUARD. Catalogue raisonné des lichens du Mont-Dore et de la Haute-Vienne. *Bull. Soc. Bot. France* 25: 321-536. 1878.
- Leight.** LEIGHTON, WILLIAM ALLPORT. *Notulae lichenologicae*. *Ann. Mag. Nat. Hist.* III. 17: 58-65; 183-190; 270-274; 348-351; 437-444. 1866. 18: 23-24; 103-106; 169-171; 306-321; 405-420. 1866.
- Leight. Lich. Fl. Great Brit.** LEIGHTON, WILLIAM ALLPORT. The lichenflora of Great Britain, Ireland, and the Channel Islands. Shrewsbury, 1871. 12mo. LLOYD.
ed. 2. Shrewsbury, 1872. 8°.
ed. 3. xviii, 547 p. Shrewsbury, printed for the author, 1879. 23 cm. FINK. AGR.
- Lightf. Fl. Scot.** LIGHTFOOT, JOHN. *Flora Scotica: or a systematic arrangement, in the Linnaean method, of the native plants of Scotland and the Hebrides*. 2 v. London, B. White, 1777. 22 cm. LC.
v. 1. 1 p. 1. xli, 530 p. 23 pl.; v. 2. 2 p. 1. p. 531-1151. 12 l. pl. 24-35.
ed. 2. 2 v. London. R. Faulder, 1789. 21.5 cm.
v. 1. 1 p. 1. xli p. 1 l. 530 p. 23 pl.; v. 2. 2 p. 1. p. 531-1151. 12 l. pl. 24-35. LLOYD. AGR.
- Lindau,** GUSTAV. Index nominum omnium receptorum atque synonymorum nec non iconum quae Nylanderii Synopsis lichenum complectitur. 1 pl. 37 p. Berlin, W. Junk, 1907. 25 cm. FINK. AGR.
- Link, Beitr. Naturgesch.** LINK, HEINRICH FRIEDRICH. Beiträge zur naturgeschichte. 1794-1801.
- Linnaea.** Ein journal für die botanik in ihrem ganzen umfange. Oder: beiträge zur pflanzenkunde. AGR.
- L. Sp. Pl.** LINNÉ, CARL VON. *Species plantarum, exhibentes plantas rite cognitatas ad genera relatas, cum differentiis specificis, nominibus trivialibus, synonymis selectis, locis natalibus, secundum systema sexuale digestas*. 2 v. 6 p. 1. p. 1-560. 1 l. p. 561-1200. 16 l. Holmiae, impensis Laurentii Salvii, 1753. 20 cm. LLOYD. AGR. NM.
ed. 3. 2 v. in 1. 1 p. 1. [12], 784 p. 1 l. p. 785-1682. [64 p.] 1 l. Vindobonae, Typis Joannis Thomae de Trattner, 1764. 20.5 cm. AGR.
- L. Mant. Pl.** LINNÉ, CARL VON. *Mantissa plantarum. Generum editionis vi, et Specierum editionis ii*. p. 1-142. 4 l. p. 144-587. Holmiae, Impensis Direct. Laurentii Salvii, 1767-1771. LLOYD. AGR. NM.
- L. Syst. Nat.** LINNÉ, CARL VON. *Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Editio duodecima, reformata*. 3 v. in 4. Holmiae, Impensis direct. Laurentii Salvii, 1766-1768. 20.5 cm. AGR. NM.
Botany v. 2. 142 p. 1 l. 1767. v. 3. p. 229-236. 1768.

- L. Suppl. Pl.** LINNÉ, CARL VON. *Supplementum plantarum systematis vegetabilium editionis decimae tertiae, Generum plantarum editionis sextae et specierum plantarum editionis secundae.* 8 p. l. 467 p. Brunswigae, impensis Orphanotrophi, 1781. 20.5 cm. LLOYD. AGR.
- L. Syst. Veg.** LINNÉ, CARL VON. *Systema vegetabilium. Editio decima sexta, curante Curtio Sprengel.* 5 v. suppl. Gottingae, sumtibus librariae Dieterichianae, 1825-1828. 20.5 cm. AGR.
v. 1. vi, 992 p. 1825. v. 2. 1 p. l. 938 p. 1825. v. 3. 2 p. l. 936 p. 1826. v. 4. 2 p. l. 592 p. 1827. v. 4. 1 p. l. 410 p. 1827. v. 5. Index 1 p. l. 749 p. 1828. Antonio Sprengel..
- Tentamen supplementum.* Antonio Sprengel. 2 p. l. 35 p. 1828. AGR.
- Lond. Journ. Bot.** The London Journal of Botany; containing figures and descriptions of such plants as recommend themselves by their novelty, rarity, history, or uses; together with botanical notices and information, and occasional memoirs of eminent botanists; by Sir W. J. Hooker. AGR.
- Lönnr.** LÖNNROTH, KNUT JOHANN. *Descriptiones generum specierumque lichenum, quas novas invenit vel limitibus novis determinavit.* *Flora* 4: 1611-620; 627-635. 1858.
- Mack. Fl. Hibern.** MACKAY, JAMES TOWNSEND. *Flora Hibernica, comprising the flowering plants, ferns, characeae, musci, hepaticae, lichens, and algae of Ireland arranged according to the natural system; with a synopsis of the genera according to the Linnæan system.* xxxiv p. 2 l. 279 p. Dublin, William Curry, Jun. and Company. [etc. etc.] 1836. 23 cm. LLOYD. AGR.
- Mann, Lich. Bohem.** MANN, WENZESLAUS. *Lichenum in Bohemia dispositio succinctaque descriptio.* 100 p. Pragae, Sommer, 1825. 8°. LLOYD.
- La Marck,** JEAN BAPTISTE ANTOINE PIERRE, AND CANDOLLE, AUGUSTIN PYRAMUS DE. *Flore française, ou descriptions succinctes de toutes les plantes qui croissent naturellement en France, disposées selon une nouvelle méthode d'analyse, et précédées par un exposé des principes élémentaires de la botanique.* éd. 3. 5 v. in 6. Paris, H. Agasse, An 1805-15. LC.
v. 1. Port. xvi, 388 p. tab. 11 pl. v. 2. xii, 460 p. fold. map. v. 3. 1 p. l. 731 p. v. 4. 1 p. l. 400 p. 4. 1 p. l. p. 400-944. 1 l. 1805. v. 5. 662 p. 1815. (chez Duray, Libraire.) 22.5 cm.
- Mass.** MASSALONGO, ABRAMO BARTOLOMMEO. *Sporodictyon, novum lichenum genus.* *Flora* 35: 321-328. pl. 4. 1852.
- Mass.** MASSALONGO, ABRAMO BARTOLOMMEO. *Synopsis lichenum Blasteniospororum.* *Flora* 35: 545-576. 1852.
- Mass. Ric. Lich.** MASSALONGO, ABRAMO BARTOLOMMEO. *Ricerche sull' autonomia dei licheni crostosi e materiali pella loro naturale ordinazione.* xiv, 207 p. 64 pl. Verona, O. Frizierio, 1852. 24.5 cm. FINK. AGR.
- Mass.** MASSALONGO, ABRAMO BARTOLOMMEO. *Amphoridium, novum lichenum genus.* *Atti Ist Veneto* II. 3: 172-181. f. 1-5. 1852. [June.] *Flora* 35: 593-598. 1852. [Oct.]
- Mass. Mem. Lich.** MASSALONGO, ABRAMO BARTOLOMMEO. *Memorie lichenografiche, con un' appendice alle ricerche sull' autonomia dei licheni crostosi.* Verona, H. F. Münster, 1853. 23.5 cm. PHIL. ACAD. AMHERST. LLOYD. GH. AGR.
- Mass.** MASSALONGO, ABRAMO BARTOLOMMEO. *Synopsis lichenum Blasteniosporum.* *Flora* 35: 561-576. 1852. [Sept.] *Atti Ist. Veneto* II. 4: App. 3. 1-131. 36 f. 1853.
Reprinted. 16 p. Ratisbon, 1852.

- Mass. Symm. Lich.** MASSALONGO, ABRAMO BARTOLOMMEO. *Symmicta lichenum novorum vel minus cognitorum*. 136 p. Veronae, Typis Antonellianis 1855. 15.5 cm. FARL.
- Mass. Sched. Crit. Lich. Exsicc.** MASSALONGO ABRAMO BARTOLOMMEO *Schedulae criticae in lichenis exsiccatis Italiae*. (vols. 1-10. nos. 1-360.) 188 p. Veronae, Typis Antonellianis. 1855[-1856]. 25.5 cm. LLOYD.
- Mass.** MASSALONGO, ABRAMO BARTOLOMMEO. Si presenta il seguente esame comparativo di alcuni generi di licheni. *Atti Ist. Veneto* III. 5: 247-276; 313-337. 1860.
- Medd. Soc. Faun. Flor. Fenn.** Meddelanden af Societas pro fauna et flora Fennica. AGR.
- Mem. Acc. Sci. Torino.** Memorie della Reale Accademia delle scienze di Torino. SC.
- Mém. Mus. Hist. Nat. Strasb.** Mémoires de la Société du Muséum d'histoire naturelle de Strasbourg. SC.
- Mém. Soc. Acad. Maine et Loire.** Mémoires de la Société Académique de Maine et Loire. Angers. SC.
- Mém. Soc. Phys. Hist. Nat. Genève.** Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. FINK. AGR.
- Mém. Soc. Sci. Nat. Cherb.** Mémoires de la Société des Sciences Naturelles de Cherbourg. SC.
- Merat, Nouv. Fl. Paris.** MERAT DE VAUMARTOISE, FRANÇOIS VICTOR. Nouvelle flore des environs de Paris, suivant la méthode naturelle, avec l'indication des vertus des plantes usitées en médecine. éd. 2. 2 v. Paris, Mequignon-Marvis, 1821. 14 cm. GH.
- v. 1. Cryptogams, 2 p. 1. iii, 292 p. v. 2. Phanerogams, 2 p. 1. xiii, 468 p.
- Meyen & Flot.** MEYEN, JULIUS, AND FLOTOW, JULIUS. Lichenes in F. J. F. Meyenii observationes botanicas, in itinere circum terram institutas. *Nov. Act. Acad. Caes. Leop. Car. Suppl.* 19¹: 209-232. pl. 3-4. 1843. AGR.^a
- Meyer, Nebenstunden.** MEYER, GEORG FRIEDRICH WILHELM. Nebenstunden meiner beschäftigungen im gebiete der pflanzenkunde. xi p. 1 l. 372 p. 2 pl. Göttingen, 1825. 21 cm. Mo. BG.
- Erster theil: die Entwicklung, metamorphose und fortpflanzung der flechten, in anwendung auf ihre systematische anordnung, und zur nachweisung des allgemeinen ganzes der formbildung in der unteren ordnungen der kryptogamischen gewächse. (All published.)
- Michx. Fl. Bor. Amer.** MICHAUX, ANDREAS. Flora Boreali-Americana, sistens caracteres plantarum quas in America septentrionali collegit et detexit. 2 v. text, plates. Parisiis et Argentorati, apud fratres Levrault. Anno xi-1803. 21 cm. MINN. AGR.
- v. 1. x, 330 p. 29 pl. v. 2. 2 p. 1. 340 p. 11. pl. 30-51.
- Miller, KATY A.** The lichens of "The Ledges," Boone County, Iowa. *Proc. Iowa Acad.* 11: 139-146. 1904.
- Contains two new names and a new variety by Bruce Fink.
- Minn. Bot. Stud.** Minnesota Botanical Studies. (Geological and Natural History Survey of Minnesóta.) FINK. AGR.

- Mont.** MONTAGNE, JEAN FRANÇOIS CAMILLE. Description de plusieurs nouvelles espèces de cryptogames découvertes par M. Gaudichaud dans l'Amérique méridionale. *Ann. Sci. Nat.* II. 2: 368-380. pl. 16. f. 1-3. 1834.
- Mont.** MONTAGUE, C. See Webb & Berth. *Hist. Nat. Canar.*
- Mont. & Berk.** MONTAGNE, JEAN FRANÇOIS CAMILLE, AND BERKELEY, MILES JOSEPH. On *Thysanothecium*, a new genus of lichens. *Lond. Journ. Bot.* 5: 257-258. pl. 10. 1846.
- Mudd, Man. Brit. Lich.** MUDD, WILLIAM. A manual of British lichens, containing descriptions of all the species and varieties, and five plates, with figures of the spores of one hundred and thirty species, illustrative of the genera. viii, 309, xxii p. 5 col. pl. Harrison Penney, Darlington, 1861. 25.5 cm. LC.
- Mudd, Mon. Brit. Clad.** MUDD, WILLIAM. A monograph of the British *Cladoniae*, illustrated with dried specimens of eighty species and varieties. vii, 36 p. 36 l. Cambridge, Harrison Penney, 1865. FARL. PSNH.
- Müll. Arg.** MÜLLER, JEAN (of Argau). Principes de classification des lichens des environs de Genève. *Mém. Soc. Phys. Hist. Nat. Genève* 16: 343-435. pl. 1-3. 1862.
- Müll. Arg.** MÜLLER, JEAN (of Argau). Lichenologische beiträge. *Flora* 64: 100-112. 1881.
- Naturw. Anz. Schw. Ges.** Naturwissenschaftliche anzeiger (Allgemeine) schweizerische gesellschaft für die naturwissenschaften. PHIL. ACAD. HC. NM.
- Neck. Meth. Musc.** NECKER, NOEL JOSEPH DE. Methodus muscorum per classes, ordines, genera ac species cum synonymis, nominibus trivialibus, locis natalibus, observationibus digestorum, aeneisque figuris illustratorum. xvii, 296 p. 1 pl. Mannhemii, ex typograph. Academ. elect. scient. 1771. 18.5 cm. NYBG. GH.
- Nees, Horae Phys. Berol.** NEES VON ESENBECK, CHRISTIAN GODOFRIED. Horae Physicae Berolinensis collectae ex Symbolis virorum doctorum H. Linkii, C. A. S. M. Rudolphi et W. Fr. Klugii, Professorum Berolinensium, C. G. Neesii ab Esenbeck, Professoris Bonnensis, Fr. Ottonis, Horti botanici regii Berolinensis inspectoris, Adalb. a Chamisso, Philosophiae Doctoris, Fr. Hornschuchii Botanices Demonstratoris Gryphici, D. a Schlechtendal, Medicinae Doctoris, et C. S. Ehrenbergii, Medicinae Doctoris. 1 pl. viii, 123 p. 2 l. 27 pl. Bonnae, Adolphi Marcus, 1820. 40.5 cm. AGR.
- Nees & Flot.** NEES VON ESENBECK, CHRISTIAN GODOFRIED, AND FLOTOW, JULIUS VON. Einige neue flechtenarten. *Linnaea* 9: 495-502. 1834.
- Neu. Journ. Bot. Schrad.** Neues Journal für die Botanik. Herausgegeben vom Professor Schrader. 4 v. in 12 pts. 1806-1810. AGR. NM.
- Norm.** NORMAN, JOHANNES MUSAEUS. Connatus praemissus redactionis novae generum nonnullorum lichenum in organis fructificationis vel spores fundalae. *Nyt Mag. Naturv.* 7: 213-252. pl. 1-2. 1853.
- Notaris, GIUSEPPE DE.** Frammenti lichenografici di un lavoro inedito. *Giorn. Bot. Ital.* 2¹: 174-224; 299-320. 1846.
- Notaris, GIUSEPPE DE.** Nuovi caratteri di alcuni generi della tribii delle Parmeliacee ed osservazioni sulla classificazione dei licheni. *Mem. Acc. Sci. Torino* II. 10: 365-389. f. 1-21. 1849.
- Not. Sällsk. Faun. Flor. Fenn.** Notiser ur Sällskapets pro fauna et flora Fennica Förhandlingar. FINK. SC. AGR.

- Nov. Act. Acad. Caes. Leop. Car.** Novorum Actorum Academiae Caesareae Leopoldino-Carolinae Naturae Curiosorum. Vratislaviae et Bonnae. SC.
- Nov. Act. Soc. Sci. Ups.** Nova Acta Regiae Societatis Scientiarum Upsaliensis. SC. AGR.
- Nuov. Ann. Sci. Nat. Bologna.** Nuovi Annali delle Scienze Naturali e rendiconto dei lavori dell' Accademia delle scienze dell' Istituto di Bologna, con appendice agraria. SC.
- Bot. Not.** Nya Botaniska Notiser. FINK. LLOYD. AGR.
- Nyl. NYLANDER, WILLIAM.** Bidrag till kännedomén om Stockholmstraktens lafvegetation, af utgifvaren. **Nya Bot. Not.** 1852: 161-180. f. 1-12. 1852.
- Nyl. NYLANDER, WILLIAM.** Observationes adhuc nonnullae ad Synopsis lichenum Holmiensium. **Nya Bot. Not.** 1853: 92-99. 1853.
- Nyl. NYLANDER, WILLIAM.** Etudes sur les lichens de l'Algérie. **Mém. Soc. Sci. Nat. Cherb.** 2: 305-344. 1854.
- Nyl. NYLANDER, WILLIAM.** Sur les fascicules de lichens d'Europe publiés par M. le Dr. Hepp. Observations critiques. **Bull. Soc. Bot. France** 1: 319-329. 1854.
- Nyl. NYLANDER, WILLIAM.** Essai d'une nouvelle classification des lichens. **Mém. Soc. Sci. Nat. Cherb.** 3: 161-202. 1855.
- Nyl. NYLANDER, WILLIAM.** Prodromus lichenographiae Galliae et Algeriae. **Act. Soc. Linn. Bord.** 21: 249-467. 1856.
- Nyl. NYLANDER, WILLIAM.** Synopsis du genre Arthonia. **Mém. Soc. Sci. Nat. Cherb.** 4: 85-104. 1856.
- Nyl. NYLANDER, WILLIAM.** Enumération générale des lichens, avec l'indication sommaire de leur distribution géographique. **Mém. Soc. Sci. Nat. Cherb.** 5: 85-146. 1857.
- Supplément. op. cit. 332-339.
Covers the whole group of lichens and upon this was based the arrangement of Nylander's Synopsis, which was never completed.
- Nyl. NYLANDER, WILLIAM.** Expositio synoptica pyrenocarpeorum. **Mém. Soc. Acad. Maine et Loire** 4: 5-88. 1858. AGR.
- Separate, 88 p. Andecavis, Cosnier et Lachèse, 1858. 21.5 cm.
- Nyl. Syn. Meth. Lich.** Synopsis methodica lichenum omnium hucusque cognitorum praemissa introductione lingua gallica tractata. v. 1. 4 p. 1. iv, 430 p. 8 col. pl. Paris. Ex typis L. Mertinet, 1858-1860. 24 cm. AGR. FINK.
- p. 1-140. 1858. p. 141-430. 1860. v. 2. p. 1-64, Pyxine to Squamaria, was also issued in 1860. For index, see Lindau, G.
- Nyl. NYLANDER, WILLIAM.** Additamentum ad lichenographiam andinum Boli-viensium. **Ann. Sci. Nat. Bot.** IV. 15: 365-382. 1861.
- Nyl. NYLANDER, WILLIAM.** Lichenes Scandinaviae. **Not. Sällsk. Faun. Flor. Fenn.** 5: 1-312. pl. 1. 1861.
- Nyl. NYLANDER, WILLIAM.** Lichenographiae Novo-Granatensis prodromus. **Act. Soc. Sci. Fenn.** 7: 415-504. 1863.
- Nyl. NYLANDER, WILLIAM.** Graphidei et Lecanorei quidam Europaei novi. **Flora** 47: 487-491. 1864.
- Nyl. NYLANDER, WILLIAM.** Novitiae quaedam lichenum Europaeorum variarum tribuum. **Flora** 48: 209-213. 1865.

Nyl. NYLANDER, WILLIAM. Adhuc novitiae quaedam lichenum Europae variarum tribuum. *Flora* 48: 353-358. 1865.

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Nyl. NYLANDER, WILLIAM. Lichenes in Brasilia a Glaziou collecti. *Flora* 52: 117-126. 1869.

Nyl. NYLANDER, WILLIAM. Observata lichenologica in Pyrenaeis orientalibus. *Flora* 55: 424-431; 545-554. 1872. 56: 65-75; 193-207. 1873.

Nyl. NYLANDER, WILLIAM. Arthoniae novae Americae borealis. *Flora* 68: 311-313; 447-449. 1885.

Nyt Mag. Naturv. Nyt magasin for naturvidenskaberne. SC.

Öfv. Vet. Akad. Förh. Öfversigt af Kongl. Vetenskaps Akademiens Förhandlingar. SC. Agr.

Oesterr. Bot. Zeitschr. Österreichische botanische zeitschrift. LLOYD. Agr.

Pers. PERSOON, CHRISTIAN HENDRIK. Einige bemerkungen über die flechten: nebst beschreibungen einiger neuen arten aus dieser familie der aftermoose. *Ann. Bot. Usteri* 7: 1-32; 155-158. pl. 1-3. 1794.

Pers. PERSOON, CHRISTIAN HENDRIK. Botanische beobachtungen, aus einem briefe. *Ann. Bot. Usteri* 14: 33-39. 1795.

Pers. Tent. Disp. Fung. PERSOON, CHRISTIAN HENDRIK. Tentamen dispositionis methodicae fungorum in classes, ordines, genera et familias. Cum supplemento adjecto. iv, 76 p. Lipsiae, apud Petrum Philippum Wolf, 1797. 18.5 cm. LC.

Pers. Icon. Descr. Fung. PERSOON, CHRISTIAN HENDRIK. Icones et descriptiones fungorum minus cognitorum. Fasciculus I-II. Lipsiae, bibliopolii Breitkopf-Haerteliani impensis. 1798-1800. 28 cm. LC.
v. 1. 2 p. 1. 26 p. 1 l. 7 pl. 1798. v. 2. 2 p. 1. p. 29-60. pl. 8-14. 1800.

Pers. Syn. Meth. Fung. PERSOON, CHRISTIAN HENDRIK. Synopsis methodica fungorum. Sistens enumerationem omnium huc usque detectarum specierum, cum brevibus descriptionibus nec non synonymis et observationibus selectis. 2 v. Gottingae, apud Henricum Dietrich, 1801. 17.5 cm. LC.
pt. 1. xxx, 240 p. pt. 2. 1 p. 1. p. 241-706. 1 l.

Poll. Hist. Pl. Palat. POLLICH, JOHANN ADAM. Historia plantarum in Palatinatu electorali sponte nascentium incepta, secundum systema sexuale digesta. 3 v. Mannhemii, apud Christ. Frid. Schwan, bibliopol. aul. 1776-1777. 19.5 cm.

LLOYD. SC.

v. 1. xxxii, 454 p. 2 fold. pl. 1776. v. 2. 664 p. 1 p. 1. 1777. v. 3. 320 p. 8 l. 1 fold. pl. 1777.

- Proc. Amer. Acad.** Proceedings of the American Academy of Arts and Sciences. AGR. NM.
- Proc. Iowa Acad.** Proceedings of the Iowa Academy of Sciences. FINK. AGR. NM.
- Rabenh.** RABENHORST, LUDWIG. Systematische übersicht der auf meiner italienischen reise beobachteten kryptogamen. *Flora* 33: 513-525; 529-537; 625-632. 1850.
- Retz. Fl. Scand. Prodr.** Retzius, Anders Johan. Florae Scandinaviae prodromus; enumerans: plantas Sueciae, Lapponiae, Finlandiae, Pomeraniae, Daniae, Norvegiae, Holsatiae, Islandiae, & Groenlandiae. 7 p. l. 257 p. 4 l. Holmiae, typis Petri Hesselberg. 1779. 20 cm. AGR.
- Riv. Per. Acc. Padova.** Rivista periodica dei lavori della I. R. Accademia di scienze, lettere ed arti di Padova. SC.
- Sagra, Hist. Nat. Cub.** SAGRA, RAMÓN DELA. Historia física, política y natural de la isla de Cuba. 12 v. pls. maps. Paris, Arthur Bertrand, 1840-1861. 40 cm. AGR. NM.
v. 9. 2 p. l. 328 p. pl. 1-10. p. [317-320 wanting]. 1845. Cryptogams. v. 10. 3 p. l. 319 p. 1845. Ranunculaceae-Loranthaceae. v. 11. 2 p. l. 339 p. 1 l. 1850. Rubiaceae-Naiadaceae. v. 12. 2 p. l. 20, 89 pl. 1855. The 20 plates of cryptogams probably issued with vol. 9 are included in this volume.
- Schaer.** SCHAEERER, LUDWIG EMANUEL. Lichenes helvetici parenchymate pulveraceo instructi. *Naturw. Anz. Schw. Ges.* 5: 33-37; 41-43. 1821.
- Schaer. Lich. Helv. Spic.** SCHAEERER, LUDWIG EMANUEL. Lichenum helveticorum spicilegium. Pars prima continens sectiones i-vii illustrantes lichenum exsiccatorum fasciculo i-xii. Pars secunda continens sectiones viii-xii illustrantes lichenum exsiccatorum fasciculos xiii-xviii. Bernae. Sumtibus auctoris excudebat officina Halloriana, 1823-1842. 24 cm. FINK. AGR.
Section 1. 3 p. l. p. i-iv, 1-52. 1823. 2. 3 p. l. p. 101-156. 1828. 4-5. 1 p. l. p. 157-261. 1833. 6. p. 263-319. 1833. 7. p. 321-380. 1836. 8. 1 p. l. p. 381-412. 1839. 9. p. 413-452. 1840. 10. p. 453-510. 1840. 11. p. 511-551. 1842. 12. p. 552-632. 1842.
- Schaer. Enum. Lich. Eur.** SCHAEERER, LUDWIG EMANUEL. Enumeratio critica lichenum europaeorum, quos ex nova methodo digerit. Front. xxxvi, 327 p. 10 col. pl. Bernae. Sumptibus auctoris excudebat officina Staempfeliana, 1850. 21 cm. FINK. AGR.
- Schleich. Cat. Pl. Helv.** SCHLEICHER, J. C. Catalogus hucusque absolutus omnium plantarum in Helvetia cis et transalpina sponte nascentium. Quas continuis itineribus in usum botanophilorum collegit; nomine genuine distinxit ac collatione cum celebriorum auctorum descriptionibus et iconibus rite facta summo studio novissime redegit. 1 p. l. 39 p. [Rex.] 1807. 20 cm. LC.
ed. 3. 48 p. [Rex.] 1815. 20 cm. LC.
ed. 4: 64 p. Camberii, ex typis Garrin et Routin. 1821. 20 cm. AGR.
- Schneider, ALBERT.** A text-book of general lichenology, with descriptions and figures of the genera occurring in the northeastern United States. xvii, 230 p. 76 pl. Binghamton, N. Y. Willard N. Clute & Company, 1897. 25 cm. FINK. AGR. NM.
- Schrad. Spic. Fl. Germ.** SCHRADER, HEINRICH ADOLPH. Spicilegium florae germanicae. 4 p. l. 194 p. 4 pl. Hannoverae, impensis Christiani Ritscheri, 1794. 20 cm. FINK. LLOYD. GREENE.
- Schrank, Baier. Fl.** SCHRANK, FRANZ VON PAULA. Baiersche Flora. 2 v. München, bey Joh. Bapt. Strobl, 1789. 19 cm. AGR.

Schreb. Spic. Fl. Lips. SCHREBER, JOHANN CHRISTIAN DANIEL. Spicilegium florum Lipsicae. 6 p. l. 148. p. 16 l. Lipsiae, prostatic bibliopolis Dykiano, 1771. 20.5 cm. AGR.

Scop. Fl. Carn. SCOPOLI, JOHANN ANTON. Flora Carniolica exhibens plantas Carnioliae indigenas et distributas in classes, genera, species, varietates, ordine Linnaeano. ed. 2. 2 v. Atlas. Vindobonae. Ioannis Pauli Krauss, 1772. 21 cm. LLOYD. AGR.

v. 1. 35 p. l. 448 p. pl. 1-32. v. 2. 1 p. l. 496 p. 8 l. pl. 33-65.

Scop. Intr. Hist. Nat. SCOPOLI, JOHANN ANTON. Introductio ad historiam naturalem sistens genera lapidum, plantarum, et animalium hactenus detecta, characteribus essentialibus donata, in tribus diversa, subinde ad leges naturae. 4 p. l. 506 p. 17 l. Prague. Apud Wolfgangum Gerle, Bibliopolam, 1777. 21.5 cm. GREENE.

S. F. Gray, Nat. Arr. Brit. Pl. See Gray, S. F.

Sommerf. Suppl. Fl. Lapp. SOMMERFELT, SÖREN CHRISTIAN. Supplementum Florae Lapponicae quam edidit Dr. Georgius Wahlenberg. 2 p. l. xii, 331 p. 3 col. pl. Christianiae. Typis Borgianis et Gröndahlianis, 1826. 20 cm. LLOYD. AGR. NM.

Sowerby, Engl. Bot. SOWERBY, JAMES. English botany; or colored figures of British plants, with their essential characters, synonyms, and places of growth. To which will be added occasional remarks by James Edward Smith. 36 v. text, col. pl. London, Richard Taylor & Co. [etc. etc.] 1790-1814. 24.5 cm. LC.

1: 1-72. Nov. 1, 1790-Nov. 1, 1792. 2: 73-144. Dec. 1, 1792-Nov. 1, 1793. 3: 145-216. Dec. 1, 1793-Nov. 1, 1794. 4: 217-288. Dec. 1, 1794-Nov. 1, 1795. 5: 289-360. Dec. 1, 1795-Nov. 1, 1796. 6: 361-432. Dec. 1, 1796-Nov. 1, 1797. 7: 433-504. Nov. 1, 1797-Nov. 1, 1798. 8: 505-576. Nov. 1, 1798-Apr. 1, 1799. 9: 577-648. Apr. 1-Oct. 1, 1799. 10: 649-720. Oct. 1, 1799-Apr. 1, 1800. 11: 721-792. Apr. 1-Oct. 1, 1800. 12: 793-864. Oct. 1, 1800-Apr. 1, 1801. 13: 865-936. Apr. 1, 1801-Oct. 1, 1801. 14: 937-1008. Oct. 1, 1801-Apr. 1, 1802. 15: 1009-1080. Mar. 1-Oct. 1, 1802. 16: 1081-1152. Oct. 1, 1802-Apr. 1, 1803. 17: 1153-1224. Apr. 1-Oct. 1, 1803. 18: 1225-1296. Oct. 1, 1803-Apr. 1, 1804. 19: 1297-1368. Apr. 1-Oct. 1, 1804. 20: 1369-1440. Oct. 1, 1804-Apr. 1, 1805. 21: 1441-1512. Apr. 1-Oct. 1, 1805. 22: 1513-1584. Oct. 1, 1805-Apr. 1, 1806. 23: 1585-1656. Apr. 1-Oct. 1, 1806. 24: 1657-1728. Oct. 1, 1806-Apr. 1, 1807. 25: 1729-1800. Apr. 1-Oct. 1, 1807. 26: 1801-1872. Oct. 1, 1807-Apr. 1, 1808. 27: 1873-1944. Apr. 1-Oct. 1, 1808. 28: 1945-2016. Nov. 1, 1808-May 1, 1809. 29: 2017-2088. May 1-Nov. 1, 1809. 30: 2089-2160. Nov. 1, 1809-June 1, 1810. 31: 2161-2232. June 1, 1810-Jan. 1, 1811. 32: 2233-2304. Jan. 1-July 1, 1811. 33: 2305-2376. July 1, 1811-Feb. 1, 1812. 34: 2377-2448. Feb. 1-Aug. 1, 1812. 35: 2449-2520. Aug. 1, 1812-Mar. 1, 1813. 36: 2521-2592. Mar. 1, 1813-Mar. 1, 1814 and index.

Supplement. London, J. D. C. and C. E. Sowerby, 1831-1849. 24.5 cm.

1: 2593-2692. Aug. 1, 1829-Apr. 1, 1831. 2: 2693-2796. June 1, 1831-Jan. 1, 1835. 3: 2797-2867. May 1, 1837-Mar. 1, 1843. 4: 2868-2960. Mar. 1, 1843-May 1, 1849.

Spreng. Anleit. SPRENGEL, KURT. Anleitung zur kenntniss der gewächse, in briefen von Kurt Sprengel. 3 v. Halle, Karl August Kümmel, 1802-4. 17.5 cm. AGR.

v. 1. 6 p. l. 421 p. 3 l. 4 fold. pl. 1802. v. 2. 3 p. l. 421 p. 2 l. 4 fold. pl. 1802. v. 3. Einleitung in das studium der kryptogamischen gewächse. 9 p. l. 374 p. 10 pl. 1804.

Spreng. Neu. Entd. SPRENGEL, KURT POLYCARP JOACHIM. Neue entdeckungen im ganzen umfang der pflanzenkunde. 3 v. Leipzig, Friedrich Fleischer, 1820-1822. 19 cm. AGR.

v. 1. iv, 452 p. 3 pl. 1820. v. 2. 2 p. l. 363 p. 3 pl. 1821. v. 3. 3 p. l. 409 p. 1822.

Spreng. Syst. Veg. See L. Syst. Veg.

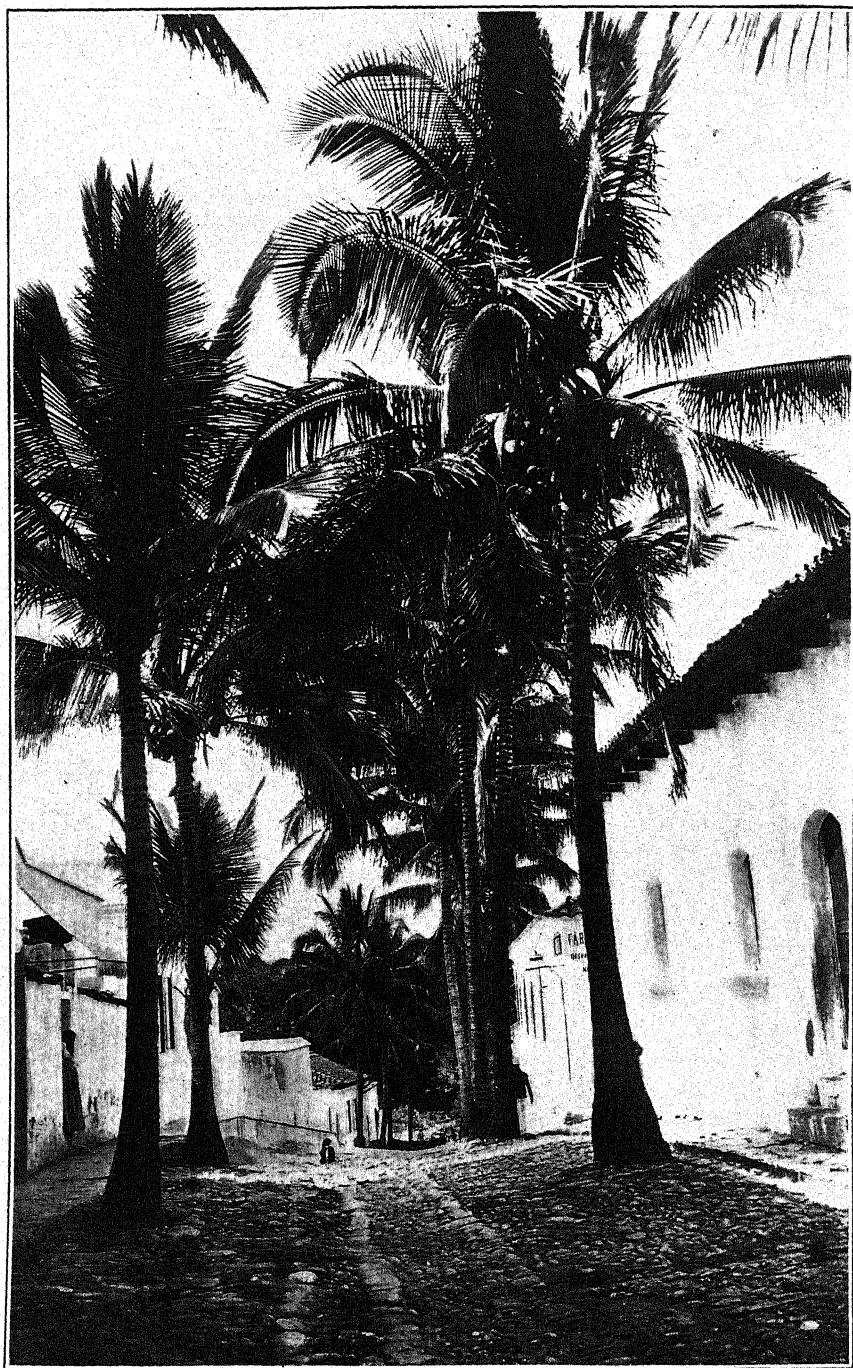
Stizenb. STIZENBERGER, ERNST. Beitrag zur flechtensystematik. Ber. St. Gall. Naturw. Ges. 1861-62: 124-182. 1862.

Sw. SWARTZ, OLOF. Musci in Suecia nunc primum reperti ac descripti. Nov. Act. Soc. Sci. Ups. 4: 239-251. 1784.

- Sw. Fl. Ind. Occ.** Flora Indiae occidentalis aucta atque illustrata sive descriptiones plantarum in prodromo recensitarum. 3 v. Erlangae. Sumt. Jo. Jacobi Palmii, 1797-1806. 22 cm. LLOYD. AGR.
v. 1. viii, 640 p. 1797. v. 2. 1 p. 1. p. 641-1230. 1 l. 1800. v. 3. 1 p. 1. p. 1231-2018. x p. 1806.
- Th. Fr. Ster. et Pil. Comm.—Gen. Het. Eur.—Lich. Scand.** See Fries, T. M. Thunb. Prodr. Pl. Cap. THUNBERG, CARL PEHR. Prodromus plantarum capensium, quas in promontorio bonae spei africes annis 1772-1775 collegit. Upsaliae, Joh. Edman, 1794-1800. ASH. GH.
Pars prior. 6 p. 1. 83 p. 3 pl. 1794. 21 cm. Pars posterior. 4 p. 1. p. 85-191. 1800. 22.5 cm.
- Trans. Linn. Soc. Lond.** Transactions of the Linnaean Society of London. SC.
- Trevis.** TREVISAN, VICTOR. Della supposta identità specifica de' licheni riunita dallo Schaerer sotto al nome de Lecidea microphylla. Nuov. Ann. Sci. Nat. Bologna III. 3: 452-465. 1851.
- Trevis.** TREVISAN, VICTOR. Saggio di una classazione naturale dei licheni. Memoria I. Sulla tribu delle Patellariee. Riv. Per. Acc. Padova 1: 237-271. 1853.
Memoria II. Sulla tribu delle Lecideine. Riv. Per. Acc. Padova 1: 351-352. 1853.
- Trevis. Caratt. Gen. Collem.** TREVISAN, VICTORE. Caratteri di tre nuovi generi de Collemaceae. 4 p. Padova, 1853.
Very rare. Not located in U. S. or in England.
- Trevis.** TREVISAN, VICTORE. Brigantiaea, novum lichenum genus. Linnaea 28: 283-287. 1856.
- Trevis.** TREVISAN, VICTORE. Genera itaque Biatorearum, quorum characteres essentiales subjungo, sequentia sunt. op. cit. 287-298.
- Triana & Planch.** TRIANA, JOSÉ, ET PLANCHON, JULES EMILE. Prodromus florum Novo-Granatensis ou énumération des plantes de la Nouvelle-Grenade. Ann. Sci. Nat. Bot. IV. 19: 286-382. 1863. 20: 228-300. 1863.
Lichens by William Nylander. 19: 286-382; 20: 228-279.
Charae by William Nylander. 20: 280-281.
Fungi by J. H. Leveille. 20: 282-300.
- Tuck. Enum. N. A. Lich.** TUCKERMAN, EDWARD. An enumeration of North American lichenes, with a preliminary view of the structure and general history of these plants, and of the Friesian system: to which is prefixed an essay on the natural systems of Oken, Fries, and Endlicher. vi, 59 p. Cambridge: John Owen, 1845. 20 cm. SC.
- Tuck. Syn. Lich. N. E.** TUCKERMAN, EDWARD. A synopsis of the lichenes of New England, the other northern states, and British America. v, 93 p. Cambridge: George Nichols, 1848. 24.5 cm. AGR.
- Tuck.** TUCKERMAN, EDWARD. Supplement to an enumeration of North American lichens; part first, containing brief diagnosis of new species. Amer. Journ. Sci. II. 25: 422-430. 1858.
- Tuck.** TUCKERMAN, EDWARD. Observations on North American and other lichens. Proc. Amer. Acad. 4: 383-422. 1862. 6: 263-287. 1865. 12: 166-185. 1877.
- Tuck. Lich. Calif.** Lichens of California, Oregon, and the Rocky Mountains so far as yet known. With an appendix. 35 p. Amherst, Mass., J. S. & C. Adams, 1866. 21 cm. AGR.

- Tuck. Gen. Lich.** TUCKERMAN, EDWARD. Genera lichenum: an arrangement of the North American lichens. xv, 281 p. 1 l. Amherst, Edwin Nelson, 1872. 23 cm. MINN. FINK. AGR.
- Tuck. Syn. N. A. Lich.** TUCKERMAN, EDWARD. A synopsis of the North American lichens. Part I, comprising the Parmeliacei, Cladonieae, and Coenogonieae. xx, 261 p. Boston, S. E. Cassino, 1882. 22.5 cm. Part II, comprising the Lecideaceae, and (in part) the Graphidaceae. 176 p. New Bedford, E. Anthony & Sons, 1888. 22 cm. MINN. FINK. AGR.
- Tul.** TULASNE LOUIS RÉNÉ. Mémoire pour servir à l'histoire organographique et physiologique des lichens. *Ann. Sci. Nat. Bot.* III. 17: 5-128; 153-249. pl. 1-16. 1852.
- Turn.** TURNER, DAWSON. Descriptions of four new British lichens. *Trans. Linn. Soc. Lond.* 7: 86-95. pl. 8. 1804.
- Turn.** TURNER, DAWSON. Description of a new species of lichen. *Trans. Linn. Soc. Lond.* 8: 260-263. pl. 1807.
- Turn.** TURNER, DAWSON. Descriptions of eight new British lichens. *Trans. Linn. Soc. Lond.* 9: 135-150. pl. 10-13. 1808.
- Vent. Tabl. Reg. Veg.** VENTENAT, ETIENNE PIERRE. Tableau du règne végétal selon la méthode de Jussieu. 4 v. Paris, J. Drisonnier. An vii. [1799.] AGR. v. 2. 2 p. 1. 607 p.
- Vet. Akad. Handl.** Kongl. Vetenskaps Akademiens Handlingar. SC.
- Vet. Akad. Nya Handl.** Kongl. Vetenskaps Akademiens Nya Handlingar. SC.
- Vill. Hist. Pl. Dauph.** VILLARS, DOMINIQUE. Histoire des plantes de Dauphiné. 3 v. Grenoble, chez l'auteur. [etc. etc.] 1786-1789. 22 cm. AGR.
- Wahl. Fl. Lapp.** WAHLENBERG, GORAN. Flora Lapponica exhibens plantas geographice et botanice consideratas, in Lapponiis Suecicis scilicet Umensi, Pitensi, Lulensi, Tornensi et Kemensi nec non Lapponiis Norvegicis scilicet Nordlandia et Finmarkia utraque indigenas, et itineribus annorum 1800, 1802, 1807, et 1810 denuo investigatas. lxvi p. map. tab. 550 p. 30 pl. Berolini, in taberna Libraria scholae realis. 1812. 22.5 cm. AGR. NM.
- Wainio, EDWARD AUGUST.** Adjumenta ad lichenographiam Lapponiae fennicae atque Fenniae borealis. *Medd. Soc. Faun. Flor. Fenn.* 6: 77-182. 1881. 10: 1-230. 1883.
- Wainio, EDWARD AUGUST.** Monographia Cladoniarum universalis. *Act. Soc. Faun. Flor. Fenn.* 4: 509. 1887. 10: 1-498. 1894. 14: 1-268. 1897.
In three parts as above. Parts 1-2, systematic with index; part 3, generalities.
- Wainio, EDWARD AUGUST.** Étude sur la classification naturelle et la morphologie des lichens du Brésil. *Act. Soc. Faun. Flor. Fenn.* 7: i-xxix, 1-243. 1890.
- Wallr. Naturgesch. Flecht.** WALLROTH, CARL FRIEDRICH WILHELM. Naturgeschichte der flechten. Nach neuen normen und in ihrem umfange. 2 v. Frankfurt am Main, Friedrich Wilmans, 1825-1827. 22.5 cm. LLOYD. MO. BG. v. 1. lviii, 722 p. 1 l. 1825. v. 2. xvi, 518 p. 1 l. 1827.
- Wallroth, CARL FRIEDRICH WILHELM.** See BLUFF, M. A., AND FINGERHUTH, C. A.
- Webb & Berth. Hist. Nat. Canar.** WEBB, PHILIP BARKER, AND BERTHELOT, SABIN. Histoire naturelle des îles Canaries. 3 v. Paris, Bethune, 1836-1844. 34.5 cm.
v. 1. pt. 1. port. 2 p. 1. 335 p. 1 l. 2 pl. 1842. pt. 2. 2 p. 1. 251 p. 1839. v. 2. pt. 1. 2 p. 1. 417 p. 1 l. 1839. pt. 2. 2 p. 1. 12, 48 p. 4 pl. 5 p. 1 l. 1 pl. 109 p. 1 l. 25 pl. 119 p. 8 pl. 152 p. 14 pl. 1836-1844. v. 3. pt. 1. sect. 1. La géographie botanique. Port. 2 p. 1. 181 p. 1 l. 20 pl. 1840. sect. 2. Phytographia Canariensis. front. 1 p. 1. 220 p. 18 pl. 1836-1840. pt. 2. sect. ultima. [Plantes cellulaires, par Camillo Montagne]. 2 p. 1. xv, 208 p. 9 pl. 1840.

- Weber & Mohr, Beitr. Naturk.** WEBER, FRIEDRICH, UND MOHR, DANIEL MATTHIAS HEINRICH. Heinrich. Beiträge zur naturkunde. In verbinding mit ihren freunden verfasst. 2 v. Kiel, in der neuen akademischen Buchhandlung, 1805-1810. SC.
v. 1. xii, 356 p. 7 pl. 1805. v. 2. vi, 400 p. 1. l. 4 pl. 1810. (bei August Schmidt.)
- Weig. Obs. Bot.** WEIGEL, CHRISTIAN EHRENFRIED. Observationes botanicae quas ammente gratiosa facultate medica in alma gryphica publice defendet. 4 p. 1. 51 p. 2. 3 pl. Gryphiswaldiae, litteris A. F. Rose, 1772. 22.5 cm. LLOYD. GH.
- Weiss, Pl. Crypt. Gott.** WEISS, FRIEDRICH WILHELM. Plantae Cryptogamicae florum Gottingensis. 3 p. 1. xiii, 333 p. 1 fold. pl. Gottingae, sumtibus viduae arb. Vandenhoeck, 1770. 19.5 cm. GREENE. NM.
- Wendt. Therm. Warmbr.** WENDT, JOHANN. Die thermen zu Warmbrunn in Schlesischen riesengebirge. Front. xvi, 320 p. Breslau, bei Goschorsky [etc. etc.] 1840. 22 cm. SURG.
Botany by C. G. Nees von Esenbeck, p. 41-114.
- Westr.** WESTRING, JOHAN PETER. At af de fleste lef-arten (lichenes) bereda fargestoffer, som satta hoga och vackra fargor pa ylle och silke, andra afdelningen innehallande forsoken med lichenes imbricati. Vet. Akad. Nya Handl. 12:293-307. 1791.
- Wigg. Prim. Fl. Hols.** WIGGERS, FRIEDRICH HEINRICH. Primitiae florum Holstatae quas praeside D. Joh. Christiano Kerstens. 3 p. 1. 112 p. 1 l. Kiliae, Litteris Mich. Frider. Bartschii Acad. Typogr. 1780. 18.5 cm. HOLM.
- Willd. Fl. Berol. Prodr.** WILLDENOW, KARL LUDWIG. Florae Berolinensis prodromus secundum systema Linneanum ab illustri viro ac Eq. C. P. Thunbergio emendatum conscriptus. xvi, 440 p. 7 pl. Berolini. Impensis Wilhelmi Viewegii, 1787. 20.5 cm. LLOYD. AGR.
- Wiley. Syn. Arth.** WILEY, HENRY. A synopsis of the genus Arthonia. 1 p. 1. vi p. 11. 62 p. New Bedford, Mass., E. Anthony & Sons, 1890. 24 cm. MO. BG.
- With. Arr. Brit. Pl.** WITHERING, WILLIAM. An arrangement of British plants; according to the latest improvements of the Linnaean system. To which is prefixed, an easy introduction to the study of Botany. ed. 3. 4 v. London, M. Swinney, 1796. 21.5 cm. LLOYD. AGR.
v. 1. xii, 402 p. 16 pl. v. 2. 1 p. 1. 512 p. pl. 20-28. v. 3. 1 p. 1. p. 513-920. pl. 29-30. v. 4. 1 p. 1. Front. 418 p. pl. 17, 18, 31 col.
- Zwackh, Wilhelm, Ritter von.** Enumeratio lichenum florum Heidelbergensis. Ein beitrage zur flora der Pfalz. Flora 45: 465-474; 481-495; 504-512; 518-527; 530-537; 546-552; 561-572. 1862.



COCONUT PALMS AT SALAMA, GUATEMALA.

HISTORY OF THE COCONUT PALM IN AMERICA.

By O. F. COOK.

INTRODUCTION.

Many scientific text-books and works of reference support the popular idea that the coconut palm is specially adapted to tropical seacoasts and is confined to maritime regions. No other example of special adaptations of plants to their environments has had longer currency or more confident belief. Nevertheless, it seems that the botanical romance of the coconut, protected by its thick husk and floated from island to island in advance of human habitation, must go the way of many other pleasing traditions. What natural agencies have been supposed to do for the coconut is now to be recognized as the work of primitive man. The truth proves again to be stranger than the fiction.

The coconut exists in the lowland tropics only as a product of cultivation. It does not plant or maintain or distribute itself on tropical seacoasts, and would entirely disappear from maritime localities if human care were withdrawn. The habits of the palm from the botanical standpoint, its significance in human history, and even its agricultural possibilities are misunderstood unless we are able to lay aside the maritime tradition.

An outline of the evidence for the American origin of the coconut palm and of its distribution by human agencies has been published in a previous number of the Contributions.^a The present study carries the subject further in two principal directions. It brings additional facts to show that the coconut palm was already widely distributed in the New World before the arrival of the Europeans, and that it is not naturally a maritime or humid tropical species, but a native of drier and more temperate plateau regions in South America. A comparison of the habits of germination of the coconut with those of other related American palms shows other and very different uses

^a The Origin and Distribution of the Cocoa Palm, Contributions from the National Herbarium, vol. 7, pp. 257-293. (1901.)

for the characters that have been looked upon as special adaptations for maritime dissemination.

The huge seed with its immense store of food materials and its thick fibrous husk make it possible for the coconut to propagate itself in the relatively dry interior localities where it appears to have originated. The inability of the palm to withstand shade explains why it has been unable to establish itself as a wild plant on any tropical seacoast. The application of these facts to cultural problems shows that the possibilities of an extratropical extension of the coconut palm are not to be realized on seacoasts, but in interior desert regions where larger amounts of heat and sunlight are to be obtained.

Though the biological evidence of the American origin of the coconut palm appears complete and adequate, recent years have brought to light several additional facts which may be of use to those whose training and habits of thought lead them to attach great weight to the historical arguments of De Candolle and other writers who believed in the Old World origin of this palm and its dissemination by the sea. The reader is impressed by De Candolle's references to many old and rare books, and will naturally remain loth to believe that so eminent an authority could have come to an erroneous conclusion, unless all the foundations of his opinions are carefully reexamined.

It is important to trace and clear away any mistakes or false deductions which obscure the early history of cultivated plants. Misconceptions regarding the origin and dissemination of any important economic species tend to distort human history as well as to mislead botanical and agricultural investigation. It is only when we view the past with the right perspective that we gain correct ideas of the factors which control our present interests and our future progress. Civilization itself is based on cultivated plants, and history may be written with as much propriety from the agricultural standpoint as from the military, political, or commercial.

Many of the plants valued by primitive man have found no place in our civilization, but have gone more or less completely out of use, either because other species of better quality or more abundant yield have taken their places, or because their uses have been outgrown. The coconut does not belong among the plants of waning importance. Its cultivation is being extended in many parts of the Tropics, and its products are rapidly gaining places in the domestic economy of the most civilized nations of Europe and America. The probability is great that the coconut palm will be recognized eventually as a food plant of the first rank, not merely by the natives of the Malayan and Polynesian islands, but by the whole civilized world.

Coconuts are an important product in Porto Rico, Hawaii, and the Philippines. A coconut industry has been established in southern

Florida, and is now beginning to attain considerable proportions. One of the Florida coconut planters is recently reported to have sold the crop of a single season for \$15,000. There is also a possibility, still entirely untried, that hardy varieties of the coconut palm can be obtained in South America which can be cultivated in southern California and Arizona, or even in a few spots in southern Texas where flowing artesian wells of warm water may make it possible to protect small areas from frost.

ALLEGED INTRODUCTION OF THE COCONUT PALM BY EUROPEAN COLONISTS.

De Candolle held the opinion that the coconut palm was introduced into South America and the West Indies* by European settlers, and that it existed in pre-Spanish America only on the Pacific coast of the Panama region. The presence of even these coconuts in America was supposed to represent a recent arrival by sea from the Pacific islands. He says:

The cocoa-nut abounds on the littoral of the warm regions of Asia, of the islands to the south of this continent, and in analogous regions of Africa and America; but it may be asserted that it dates in Brazil, the West Indies, and the west coast of Africa from an introduction which took place about three centuries ago. . . .

The inhabitants of the islands of Asia were far bolder navigators than the American Indians. It is very possible that canoes from the Asiatic islands, containing a provision of cocoa-nuts, were thrown by tempests or false manoeuvres on to the islands or the west coast of America. The converse is highly improbable.

The area for three centuries has been much vaster in Asia than in America, and the difference was yet more considerable before that epoch, for we know that the cocoa-nut has not long existed in the east of tropical America.^a

This supposed limitation of the range of the coconut palm in ancient America, while not necessarily disproving its origin on this continent, might stand in the way of any full confidence in the American nativity of the species. But if it can be shown that there is adequate historical evidence of the existence and wide distribution of the coconut in tropical America at the time of the discovery, we gain a different idea of the status of the palm among the natives of America. De Candolle was able to entertain the opinion that the coconut did not exist on the eastern side of the American Continent before the Spanish discovery because he overlooked several important early references and because he relied upon the theory of an early Spanish introduction to explain the historical facts with which he was acquainted.

No direct evidence of such an introduction has been produced, nor does a canvass of the references to the early accounts of America cited by De Candolle reveal any facts which support the assertion, even indirectly. There were no coconuts in the Mediterranean region

^a De Candolle, A., *Origin of Cultivated Plants*, ed. 2, pp. 430, 433. (London, 1886.)

which the Spaniards could bring to America, and they had no facilities for securing coconuts from the East Indies. And even if they had been able to arrange such an importation through their jealous competitors, the Portuguese, the time required in those days for the necessary sea voyages would have been too long.

A motive for such an introduction was lacking, as well as an opportunity. It does not appear that any of the early discoverers or historians were familiar with the coconut before coming to America, and they evidently did not become acquainted with it here as an important article of food or as having any other value that would lead them to give it their active attention and care. The agricultural activities of the Spanish colonists took the direction of introducing European plants into America, in the hope of being able to supply themselves with their accustomed foods. The appreciation of the new foods and other products of the agricultural plants that were natives of America and the introduction of American plants into Europe went on only slowly and casually.

There is nothing to show that tobacco or potatoes reached Europe until after the middle of the sixteenth century. Indian corn and capsicum pepper were known in Germany by 1543, as described by Fuchs, but in both these cases it is possible to doubt whether the plants were post-Columbian introductions from America or pre-Columbian arrivals from the Orient, as indicated by the early histories and by their earliest European names.^a Columbus himself began the introduction of European plants into America, but the only tropical types introduced during the period of the early discoveries appear to have been the varieties of bananas and sugar cane brought over from the Canary Islands.

The Malayan and Polynesian islands, where the coconut is a plant of the first rank, were still undiscovered by Europeans, who had only vague rumors of the medicinal virtues of the *Nux Indica*, as it was termed in the medieval pharmacopœia. Even in parts of the East Indies where the coconut palm undoubtedly existed some of the early writers make little or no mention of it. Thus in the extended

^aThe history of the early introduction of American plants into Europe has been summarized by Dr. Seb. Killermann, in the *Naturwissenschaftliche Wochenschrift*, vol. 24, p. 193. (March 28, 1909.)

Doctor Killermann finds that four American plants were known in Europe before 1543, the Indian corn, the capsicum pepper, the squash (*Cucurbita maxima*), and the French marigold (*Tagetes patula*). By about the middle of the sixteenth century five other American plants had been recorded, two species of tobacco (*Nicotiana tabacum* and *N. rustica*), the prickly pear (*Opuntia*), the century plant (Agave), and the tomato. From the second half of the century there are accounts of the bean (*Phaseolus vulgaris* and *P. coccineus*), the peanut, the Jerusalem artichoke (*Helianthus tuberosus*), the spiderwort (*Tradescantia*), the nasturtium (*Tropaeolum*), and the potato. The sweet potato does not appear in this list. The first reference to its

account of Cochin China by an early Jesuit missionary, Borri, which follows the early discoveries of America in Churchill's Voyages, there is no mention of coconuts, though other plants and their products are treated in detail.

The first practical acquaintance of the Spanish with the coconut was gained in America, and we may believe that if they had undertaken to introduce the palm into the West Indies they would have brought the nuts from Panama instead of from the East Indies. But even this would have been quite outside of the objects and operations that are recorded in elaborate detail by the early historians. Any such undertaking on the part of any intelligent leader would almost certainly have become a matter of record. We find, however, no sign of interest in the plant which would render such an effort on the part of the Spaniards in any way probable.

In thus alleging an early Spanish introduction of the coconut in America De Candolle seems to have depended entirely on an inference not really warranted by facts. He argues that unless the palm were wild and indigenous it must have been introduced by Europeans, a deduction certainly unwarranted in view of the fact that numerous other species of native cultivated plants, such as Indian corn, sweet potato, cotton, capsicum, peanut, cassava, sour-sop, avocado, anatto, and cacao (chocolate) had been widely distributed through tropical America in pre-Columbian times. Like the coconut palm, most of these plants are still unknown in the wild state. They testify to the very great antiquity of agriculture in tropical America, and show the propriety of considering the coconut as one of many American plants that had been domesticated in America before the arrival of the Spaniards.

EARLY ACCOUNTS OF THE COCONUT PALM IN AMERICA.

PETER MARTYR'S ALLUSIONS TO THE COCONUT.

The only suggestion of historical warrant that De Candolle gives us for the idea of the introduction of the coconut by Europeans is contained in this statement:

Sloane says it is an exotic in the West Indies. An old author of the sixteenth century, Martyr, whom he quotes, speaks of its introduction. This probably took place a few years after the discovery of America, for Joseph Acosta saw the cocoa-nut palm at Porto Rico in the sixteenth century.^a

In reality Sloane does not express any such opinion as his own; he gives a very casual mention of an idea which he ascribes to Peter Martyr, the representative of the Pope at the court of Spain, who wrote letters about the Spanish discoveries to his friends in Italy,

^a De Candolle, A., *Origin of Cultivated Plants*, ed. 2, p. 430. (1886.)

based on information collected from the explorers and the reports they sent home. Sloane says:

Martyr says this Fruit was brought to the American Isles, but, that many were found naturally in Peru, it may be doubted whether they were not brought thither by the natural Currents of the Sea.^a

Sloane does not tell us where such a statement is to be found in Martyr's writings, nor does De Candolle appear to have considered it necessary to verify the reference for himself. A search through the English version of Martyr's *Decades* used by Sloane might have lessened confidence in the idea that the palm was introduced by the Spaniards.

The name "coco" was not mentioned by Martyr in his accounts of America, though there were many references to palms, which the early English translator turned into "date trees," the date being the only palm well known in Europe at the time. Even in the last century we find English travelers referring to Brazilian species of *Cocos* as "dates," as in the following instance:

Still we were skirting palm-trees, among which the grass grew to a great height. One of the things we had from the Indians yesterday was the date-palm. Its fruit grows in clusters, looking like a colossal bunch of grapes; the outer shell is thin, and contains a sweet, yellowish substance, of which the Indians are very fond, covering a nut like a filbert, with the flavour of the coconut, containing the kernel from which the oil is extracted.^b

In addition to the fact that both are fruits of palms, there is a notable external resemblance between dates and coconuts as they hang in large clusters among the bases of the leaves. The only striking difference is that of size, which is commonly disregarded in popular comparisons. Indeed, Martyr himself was familiar with the idea that the products of America often exceeded those of Europe in size.^c

^a Sloane, Hans, *A Voyage to the Islands Madera, Barbados, etc.*, vol. 2, p. 9. (1725.)

^b Mulhall, M. G., *Between the Amazon and Andes*, pp. 183, 184. (London, 1881.)

^c Martyr did not understand that the Indian corn of America was a different plant from the cereals of Europe, and hence found it difficult to credit the report that the wheat in Santo Domingo produced ears thicker than a man's arm.

... The lyke encrease commeth of wheate if it be sown vppon the mountaynes where the colde is of some strength: but not in the playnes, by reason of to much fatnes and rankenes of the grownde. It is in maner incredible to heare, that an eare of wheate shuld bee bygger then a mans arme in the brawne, and more then a spanne in length, bearynge also more then a thousande graynes as they all confesse with one voyce, and earnestly affirme the same with othes. Yet they say the bread of the Ilande (cauled) *Cazabbi* made of the roote of *Iucca*, to bee more holsome, because it is of easier digestion, and is cultured with lesse labour and greater increase. The residue of the tyme which they spende not in settinge and plantynge, they bestowe in gatheringe of golde.—Martire, Pietro, *The Decades of the Newe Worlde or West India* (1516), trans. by Richard Eden (1553), in Arber, E., *The First Three English Books on America*, p. 168. (Birmingham, 1885.)

While most of Peter Martyr's allusions to dates give no details that afford a botanical identification of the palm, it must be remembered that there is no other palm in the West Indian region that is more similar to the date or any other that has economic importance enough to bring it to the attention of men like Martyr and his English translator, Eden, and lead them to reckon it among the economic products of the New World. Eden seems to have been more keenly interested in such matters than Martyr and occasionally adds information from other sources to his translation of Martyr, as in the following instance:

. . . In these Ilandes they founde no trees knowen vnto them, but pyne app[le] trees, and date trees: And those of maruelous heyght and exceding harde, by reason of the greate moystnesse and fatnesse of the grounde, with continuall and temperate heate of the sonne, whiche endureth so all the hole yere.^a

There is no corresponding statement in the complete Latin text of Martyr's "Decades" published at Paris in 1587, under the title "De Orbe Novo." The interest of the passage is not destroyed by the fact that it was an interpolation, for Eden was a contemporary of Martyr and published his translation of the first three of Martyr's "Decades" before the complete edition was issued. That Eden understood Martyr's passages about palms to refer to the coconut can hardly be doubted, and there is no reason to claim that he was mistaken in such instances as the following:

This fortresse, he cauled saynt Dominikes towre. Into this hauen, runneth a ryuer of holsome water, replenyshed with sundrye kyndes of good fysshes. They affyrme this ryuer to haue many benefytes of nature. For, where so euer it runneth all thynges are excedyng pleasaunte and fruitfull: hauynge on euery syde, groues of date trees, and dyuers other of the Ilande frutes so plentyfully, that as they sayled alonge by the shore, often tymes the branches therof laden with flowres and frutes, hunge soo ouer theyr heades, that they mighte plucke them with theyr handes.^b

The phrase "groves of date trees" is justified by Martyr's Latin word *palmeta*, which also carries an implication that the groves were artificial, and not mere forests of wild palms. In another passage wild palms that grow "of themselves" are mentioned in direct contrast with those that bear "dates" larger than those of Europe, thus implying again that the latter were cultivated.

. . . They haue also abundance of nuttes of pynetrees, and great plentie of date trees, whiche beare frutes bygger then the dates that are knowen to vs: but they are not apte to bee eaten for theyr to much sowernes. Wylde and baren date trees, growe of them selues in sundry places, the branches wherof they use for biesommes, and eate also the buddes of the same.^c

The words *nucibus pineis* of the Latin original indicate that Martyr, as well as his translator, confused pines and pineapples. It does not

^a Martire in Arber, op. cit., p. 67.

^b Martire in Arber, op. cit., p. 82.

^c Martire in Arber, op. cit., p. 131.

appear that there are any pine trees in the Veragua district of Panama, to which this statement pertains, or that there are any pines with edible nuts in the whole Central American region. There are many pine forests in Mexico, Guatemala, and Honduras, but they are not known to extend farther south than the latitude of Matagalpa, Nicaragua. The botanical explorations of Professor Pittier in Costa Rica and Panama afford conclusive evidence that there are no pines in those countries. Professor Pittier also states that ineffectual attempts have been made to introduce pines into the central plateau of Costa Rica.

The word translated by Eden as "date trees" simply means palms (*palmarum*), and might possibly refer to the fruits of one of the *Attalea* palms or to those of *Elaeis melanococca*, though neither of these could be expected to have received much consideration from the standpoint of utility as food, or to have been planted by the Indians. The coconut, though hardly distinguished for sourness (*ob austeritatem*), would certainly be a disappointment as a food in comparison with the sweet fruits of the true date. Coconuts are very seldom eaten in the Tropics in a raw state except by children; as an exclusive diet they were considered very unwholesome, especially by the weakened, half-starved men of the Spanish expeditions.

OVIEDO'S ACCOUNT OF THE COCONUT.

The source of Eden's information regarding the American "dates" need not be sought further than in the extensive accounts by Oviedo, also translated by Eden and published in the same book with Martyr's "Decades."^a There can be no possible doubt that Oviedo was acquainted with the coconut palm. He described it at length in a two-page chapter of his quaint Spanish, which Eden rendered into contemporary English as follows:

There is bothe in the firme lande and the Ilandes a certeyne tree cauled *Cocus*, beinge a kynd of date trees and hauynge theyr leaues of the self same greatnesse as haue the date trees which beare dates, but dyffer much in their growynge. For the leaues of this *Cocus* grow owte of the trunkes of the tree as doo the fyngers owt of the hande, wreathyng them selues one within an other and so spreadynge abroad. These trees are hygh: and are founde in great plentie in the coaste of the sea of *Sur*, in the prouince of *Cacique Chiman*. These date trees brynge furth a frute after this sorte. Beinge altogyther vnite as it groweth on the tree, it is of greater circumference then the heade of a man. . . . Whyle this *Cocus* is yet freshe and newly taken from the tree, they vse not to eate of the sayde carnoftie and frute: But fyrste beatynge it

^a Oviedo's original publication was an abridgment entitled, *Oviedo dela natural hystoria de las Indias*. (Toledo, 1526.) This was translated by Richard Eden under the title, *The natural history of the West Indies*, and published in Arber, E., the first three English books on America. (Birmingham, 1885.) The complete work was first issued at Madrid in 1851. (See footnote, p. 295.) Books 1-19 and 10 chapters of book 50 were published in Seville, 1535, as *La historia general delas Indias*.

very much, and then straynynge it, they drawe a mylke thereof, much better and sweeter then is the mylke of beastes, and of much substaunce: The which the Christian men of those regions put in the tortes or cakes which they make of the grayne of *Maizium* wherof they make theyr breade, or in other breade as we put breade in porrage: So that by reason of the sayde mylke of *Cocus*, the tortes are more excellent to be eaten without offence to the stomake. They are so pleasaunte to the taste, and leaue it aswell satisfied as thowghe it had byn delyted with many delycate dysshes. . . . This frute was cauled *Cocus* for this cause, that when it is taken from the place where it cleaueth faste to the tree, there are seene two holes, and aboue them two other naturall holes, which altogyther, doo represente the giesture and fygure of the cattes cauled *Mammone*, that is, munkeys, when they crye: whiche crye the Indians caule *Coca*.^a

Eden's version of Oviedo also affords a clue to the mystery of Sloane's statement regarding the introduction of the coconut into America, upon which De Candolle appears to have placed so much reliance. It was Oviedo, instead of Peter Martyr, who reported the planting of dates in Santo Domingo, but these were not coconuts, but true dates from Spain, as the context shows:

Suche frutes as are brought owt of Spayne, into this Ilande, prosper maruelously and waxe rype all tymes of the yeare: as herbes of all sortes very good and pleasaunt to bee eaten. Also many pomegranates of the best kynde, and oranges bothe sweete and sower. Lykewyse many fayre Lymones and cedars: and a great quantitie of all such as are of sharpe, sowre, and bytter taste. There are also many fygge trees whiche brynge furth theyr frute all the hole yeare. Lykewyse those kynd of date trees that beare dates: and dyuers other trees and plantes which were brought owt of Spayne thither.^b

The substitution by Sloane of Peru for Panama, in the passage already quoted on page 276, may have been a mere slip of the pen, or a typographical error, for it does not appear that coconuts have ever thriven in Peru, in ancient times or modern, or that Sloane had any warrant of fact for his statement. Finally, we have the evidence of the passage just quoted, to show that Sloane confused the coconuts that were already in America with the true dates that were brought by the Spaniards from Spain. The only indication of historical warrant given by De Candolle for his theory of the Spanish introduction of the coconut into America proves to be entirely without foundation.

REPORT BY COLUMBUS OF COCONUTS IN CUBA.

Eden's version of Oviedo definitely asserts the existence of the coconut palm in the West Indies, as well as on the continent, and Oviedo's larger history includes the coconut in an account of the numerous native species found in the island of Santo Domingo, but De Candolle seems to have noticed only the mention of the special abundance of the coconut palms on the Pacific coast of Central America, which he

^a Oviedo in Arber, op. cit., p. 225.

^b Oviedo in Arber, op. cit., p. 239

contrasted with their supposed absence on the Atlantic coasts and islands. De Candolle alludes to Oviedo only in the following passage:

Oviedo, writing in 1526, in the first years of the conquest of Mexico, says that the cocoa-nut palm was abundant on the coast of the Pacific in the province of the Cacique Chiman, and he clearly describes the species. This does not prove the tree to be wild. In southern Asia, especially in the islands, the cocoa-nut is both wild and cultivated. The smaller the islands, and the lower and the more subject to the influence of the sea air, the more the cocoa-nut predominates and attracts the attention of travelers.^a

Oviedo's statement is not the only one that has to be explained if we are to deny the existence of the coconut palm in the West Indies when the Spaniards arrived. Columbus himself recorded the finding of coconuts on the north coast of Cuba, near Puerto Principe, only a little over a month after his first landing in the Bahamas.

The Admiral got into the boat, and went to visit the islands he had not yet seen to the S. W. He saw many more very fertile and pleasant islands, with a great depth between them. Some of them had springs of fresh water, and he believed that the water of those streams came from some sources at the summits of the mountains. He went on, and found a beach bordering on very sweet water, which was very cold. There was a beautiful meadow, and many very tall palms. They found a large nut of the kind belonging to India, great rats, and enormous crabs. He saw many birds, and there was a strong smell of musk, which made him think it must be there. This day the two eldest of the six youths brought from the *Rio de Mares*, who were on board the caravel *Niña*, made their escape.^b

The coconut was known to mediæval Europe only as *Nux Indica*, or Indian Nut, the name "coconut," though stated in dictionaries to be derived from Latin and Greek words meaning nut or seed, seems not to have been applied to the coconut till after the discovery of America. Other lexicographers have undertaken to derive coco from Spanish or Portuguese words meaning ape or ogre, an application which is explained by allusion to the three pits or eyes of the coconut which afford a grotesque suggestion of the face of a man or a monkey. It is quite possible, however, that the Spaniards adopted the word coco from the natives of the West Indies as they did many other names of agricultural plants, such as "mais" (Indian corn), "aji" (capsicum), "achiote" (anatto), "platano" (banana), "mani" (peanut), etc. In the case of the banana it is evident that a native word, closely resembling platano led the early explorers to suppose that the banana was the actual platano or plane tree of which the Spaniards of that time knew only the name as it occurs in the Bible. The histories written by Oviedo and Acosta both contain chapters explaining that the plane tree of Scripture was not the same as the "platano" of the West Indies.

^a De Candolle, A., *Origin of Cultivated Plants*, ed. 2, p. 431. (1886.)

^b *Journal of the first voyage of Columbus*, trans. by C. R. Markham, p. 80. (Hakluyt Society, 1893.)

Markham's translation of the clause relating to the coconuts in Cuba is not altogether satisfactory. The Spanish version says that large nuts (*nueces grandes*) were found, rather than a single nut. The statement that the nuts were of the kind belonging to India (*nueces grandes de las de India*) is followed by a parenthetical idiomatic expression (*creo que dice*), as though to remind the reader that this was the opinion of Columbus, for which the editor of the journal, Las Casas, did not wish to be considered responsible. Las Casas added a footnote (*Hutias debian de ser*, "They must have been agoutis") to indicate that the animals taken for rats by Columbus were agoutis, the large tailless rodents of Cuba. Having learned that the agoutis were not rats, the identity of the nuts might also be questioned, but no other nut has been found in Cuba large enough to be mistaken for a coconut. Knowing that Columbus had not in reality reached the East Indies, Las Casas was inclined to pass lightly over the evidences that had deceived the Admiral.

We are left with no positive assurance that the large nuts came from the very tall palms, but botanical science affords us no ground for refusing to believe that the statement relates to the coconut, as Colmeiro has declared in opposition to a Spanish historian who considered the large nuts as walnuts.^a

Markham's translation also omits a statement regarding the palms, that they were taller than any that Columbus had seen thus far, which may have reference to a previous mention of great numbers of palms (*infinitas palmas*) three days before at a location identified by Markham as Puerto de Taxamo, Cuba. If we include these emendations, the reference to the large nuts and its immediate context may be translated as follows:

There was a very beautiful meadow, and many very tall palms, taller than those seen before; he found large Indian nuts, as he would say, and large rats, also like those of India, and very large crabs.^b

Though the presence of natives is not stated, the mention of the meadow indicates that the place had been cleared by human inhabitants. It appears unlikely that the native palms, even if they had

^a Vió Colón "muchas y altísimas palmas," así como algunos pinos (*Pinus occidentalis* Sw. et. *P. cubensis* Griseb.), y después deaquéllas mencionó las "nueces grandes de las de India," que no es admisible perteneciesen á un nogal, como presumió el historiador Muñoz, siendo lo creible que fuesen cocos, porque no es improbable que el cocotero (*Cocos nucifera* L.) existiese en las regiones intertropicales del Nuevo Mundo antes de su descubrimiento, y así parece demostrarlo tan significativa indicación.—Colmeiro, Miguel, Primeras Noticias acerca de la Vegetacion Americana, p. 13. (Madrid, 1892.)

^b The Spanish text of Navarrete is as follows:

"... habia un prado muy lindo y palmas muchas y altísimas mas que las que habia visto: halló nueces grandes de las de India, creo que dice, y ratones grandes de los de India tambien, y cangrejos grandísimos. (Navarrete, Coleccion de los Viajes y Descubrimientos, etc., p. 60, Madrid, 1825.)

existed in the forest, would have attracted the attention of the explorer.

Ferdinand Columbus states that his father found "palm trees of several sorts," and mentions on a previous occasion that some had "the trunk green and smooth," which may refer to the Cuban royal palm (*Roystonea regia*).^a This could have no connection with the large nuts, for the mature fruits are only about the size of a small cherry.

One of Peter Martyr's passages relating to "dates" evidently has reference to the same incident of exploration of the north coast of Cuba by Columbus:

And when they had at the lengthe escaped these strayghtes, and were nowe coome into a mayne and large sea, and had sayled theron for the space of foure score myles, they espyed an other excedinge hygh mountayne, whyther the Admirall resorted to store his shyppes with fresshe water and fuel. Heare amonge certeyne wooddes of date trees, and pyneable trees of excedyng height he fownd two natieue sprynges of fresshe water.^b

The fantastic idea of tall "pyneable trees" arose from the failure of Europeans not familiar with America to distinguish between pine trees and pineapples. True pine trees were found in abundance in Cuba and Santo Domingo, as well as in Central America. European readers who progressed far enough to learn that pineapples had no relation to pine trees often went to the other extreme of supposing that all the early references to pines related to pineapples. Pine trees are mentioned in the Journal of Columbus in the same district with the "very tall palms" and the large "nuts of India."

If the statement of the Journal of Columbus stood alone we might well hesitate to base any general conclusion upon it, but there is certainly no reason to deny it a place among the many other statements that can be reasonably interpreted only by recognizing their relation to the coconut. As soon as we appreciate the fact that the Spaniards were not acquainted with the coconut, either in nature or in name, before their arrival in America, it becomes apparent that the statement of Columbus is as direct a piece of evidence as we could hope to get, under the existing circumstances. It is not unreasonable to believe that he knew something of the Indian nut, and of the palms that produced it, considering that he spent many years of his life in the active quest of geographical knowledge, with especial reference to the Indies, which he hoped to reach by sailing west. The most remarkable thing about this statement of Columbus is that it should have been so completely overlooked by De Candolle and other writers interested in the history of the coconut palm. Even Pickering failed to include it in his immense collection of similar facts,

^aChurchill's Collection of Voyages and Travels, vol. 2, pp. 534, 535. (London, 1732.)

^bMartire, in Arber, op. cit., p. 77. (See footnote c, p. 276.)

though he refers to the finding of coconuts by Columbus during the fourth voyage, when the coast of Central America was explored.^a

In this case an error appears to have been made, which has been copied into some of our works of reference. The only passage that it seems likely to have been interpreted in this way relates to the seeds of the cacao tree from which chocolate is made, not to the nuts of the coconut palm.^b

ABUNDANCE OF COCONUT PALMS IN PORTO RICO.

The earliest record of the coco palm in the West Indies given by De Candolle was that of Acosta, who visited America in the latter half of the sixteenth century and saw coco palms at San Juan, Porto Rico, from which De Candolle infers that the alleged introduction "probably took place a few years after the discovery of America." The context of Acosta's allusion to the coconut at San Juan does not, however, support such a conjecture, since it is apparent that Acosta, who was a learned and careful historian, was describing the coconut as a notable product of the "Indies," after spending seventeen years in America. The coconuts at San Juan, if brought by the Spaniards, even from Panama, could not have been there for many decades, so that Acosta's mention of them is better evidence against a Spanish introduction than for it.

Acosta does not say how many coco palms he saw at San Juan, but the chaplain of the Duke of Cumberland, who visited Porto Rico in 1598 gives us an account of the coconut palms of that island which would not be inapplicable at the present day, and which precludes all reasonable doubt that at the end of the sixteenth century the coco palm existed in Porto Rico in such size and in such numbers as to render incredible any recent introduction, subsequent to the arrival of the Spaniards.

The body of them is but slender, no where so bigge as a man's middle, and upwards growing proportionably lesse, till they are risen some thirtie or fortie foot high without sprig or bough, then breake out their boughs all at once, euery one whereof is iust like a goodly Ostridge feather; their leaues are so cunningly set together, euery one whereof

^a "... Eastward from the Polynesian Islands, nuts were seen by Columbus on his fourth voyage, in Central America (Churchill Collections)."—Pickering, Charles, Chronological History of Plants, p. 428.

^b For their provision they had such roots and grain as they in *Hispaniola* eat, and a sort of liquor made of *Maiz*, like the *English* beer; and abundance of *Cacao* nuts, which in *New Spain* pass for money, which they seemed to value very much; for when they were brought aboard among their other goods, I observ'd that when any of these nuts fell, they all stoop'd to take it up, as if it had been a thing of great consequence: yet at that time they seem'd to be in a manner besides themselves, being brought prisoners out of their canoe aboard the ship, among such strange and fierce people, as we are to them, but so prevalent is avarice in man, that we ought not to wonder that it would prevail upon the *Indians* above the apprehension of the danger they were in.—Churchill's Collection of Voyages and Travels, vol. 2, p. 606. (London, 1732.)

alone is something like a Sedge or the leafe of a wilde Lilly. Under this bush which is the head of the tree, doe the Coker-nuts grow, some fortie on a tree round about the Bole, some yard downward from where the branches breake out. These trees are a very great grace to the Citie of Puerto Rico, [San Juan] and very many there were found in it.^a

Samuel Champlain, the subsequent explorer of Canada, also visited Porto Rico in 1599, shortly after the English expedition had sailed away from the island. The Spanish expedition that Champlain accompanied also "remained at Porto Rico about a month," and came to the same conclusions as the English chaplain regarding the island and its palms.

The said Island of Porto-rico is pretty agreeable, although it is a little mountainous, as the following figure shows. It is filled with quantities of fine trees, such as cedars, palms, firs, palmettoes, and another kind of tree which is called sombrade. . . .^b

We might remain in doubt of what palms were intended if it were not for a later passage in which Champlain clearly distinguishes between the true palm or coconut and the cabbage or royal palms which he calls "palmiste," but not "palm."

As I have spoken of the palm, although it is a tree sufficiently common, I will here represent it. It is one of the highest and straightest trees that can be seen; its fruit, which is called "Indian nut," grows quite on the top of the tree, and is as large as the head of a man; and there is a thick green bark on the said nut, which bark being removed, the nut is found, about the size of two fists; that which is inside is very good to eat, and has the taste of young walnuts; there comes from it a water, which serves as a cosmetic for the ladies.^c

FIRST ACCOUNT OF THE COCONUT IN BRAZIL.

De Candolle knew from the writings of Piso and Marcgrave that the coconut existed in Brazil at an early date, but he did not admit that the palm was present before the European settlements were made. He treated his evidence regarding Brazil in the same way as that relating to Porto Rico, to support his assumption of an introduction by Europeans. But if we go back to the original of the earliest statement we find nothing of this implication that the coconuts had been imported by the colonists. We learn only that the palms were cultivated in Brazil, as everywhere else. De Candolle's inference from such statements is that Piso and Marcgrave "seem to admit that the species is foreign to Brazil, without saying so positively," but these authors certainly give no intimation of any idea that it was introduced into Brazil by the Portuguese. On the contrary, they both record the native Indian names, *inaiguacuiba* for the tree and *inaiguacu* for the fruit, and state that the fruit of

^aEarl of Cumberland, *Voyage to the West Indies, Purchas His Pilgrims*, vol. 4, p. 1173. (London, 1625.)

^bChamplain, Samuel, *West Indies and Mexico*, trans. by Alice Wilmere, p. 10. (Hakluyt Society, 1859.)

^cOp. cit., p. 31.

another species of Cocos native in Brazil is called *inaia mira*, or small coconut. No suspicion is betrayed that coconuts were not one of the genuine products of the country, instead of a recent importation from abroad. The statements of later writers on Brazil and Guiana, such as Aublet, Martius, Spruce, Burton, and Wallace, are in entire accord with that of Piso and Marcgrave. They do not claim that the coconut is native in eastern South America, but find it widely distributed in cultivation.

Piso's is not, however, the first reference to the coconut in Brazil, as De Candolle seems to have supposed. More direct and conclusive evidence was published nearly a quarter of a century before from a Portuguese friar who had resided in Brazil for the last three decades of the sixteenth century.^a This writing has also a direct bearing on the question of introduction by Europeans, since it contains a special enumeration of the plants brought to Brazil by the Portuguese. The coconut does not occur in this list, but is included among the native cultivated plants.

In this *Brasil* are many coco-nuts, excellent like those of *India*; these are ordinarily set, and growe not in the Woods, but in Gardens, and in their Farms. And there are more than twentie kindes of Palme trees, and almost all doe beare fruit, but not so good as the Cocos: with some of these Palme trees they couer their houses.^b

Exactly the same might have been written of the peach palm (*Guilielma*), the other indigenous palm widely cultivated in prehistoric times by the Indians of South America. But since the peach palm did not attain a world-wide distribution no question of its South American nativity has ever been raised, though it has never been found in the wild state.

The statements of the early historians that the coconut palms did not grow wild in the forest, but only where they had been planted, instead of supporting the idea of an introduction by the Portuguese colonists is better evidence to the contrary, for it becomes highly improbable that such a piece of history would have been omitted from the record. This consideration is even more conclusive in the case of Brazil than in that of Porto Rico, for in that island it might have been possible to raise the palms if the colonists had introduced them early and propagated them with care and diligence. But in Brazil there was actually no time for any multiplication and dissemination of the palms to have taken place, for the colonization of Brazil by the Portuguese did not begin till after the middle of the sixteenth century, or less than twenty years before the arrival of the writer who states their abundance.

^a The manuscript of this unknown author was captured by an English sailor in 1601, and an English translation was published in 1625 in Purchas His Pilgrims, vol. 4, p. 1289. Piso's account of the coconut in Brazil was not issued until 1648.

^b Purchas His Pilgrims, vol. 4, p. 1307.

The Portuguese are also supposed by Martius and De Candolle to have planted the coconut in their West African settlements, but for this purpose they are more likely to have brought seed from Brazil than from the East Indies.^a The slave trade brought about early and frequent communication between Angola and Brazil, and several travelers visited and described both countries. Martius, though he does not give his authorities, states that the coco palm was planted in the Portuguese settlements in West Africa. This does not prove, of course, that the coconut was unknown in West Africa before Portuguese times; nor on the other hand does the record by Marcgrave of native Congo names afford sufficient proof that the natives knew the palm before the time of the Portuguese settlements.

The coco palm continues to be planted at the European settlements and trading stations on the West Coast of Africa, but seems not to have extended itself spontaneously nor to have been adopted in cultivation, perhaps because very few of the agricultural natives live on the coast. The Kroo people of Liberia, who have maritime habits, were reported by Doctor Vogel to have superstitious fear of planting coconut palms.^b This belief seems still to prevail, for the very large Kroo town at Monrovia, though built along the beach, is shaded by no coco palms.

EARLY NOTICES OF THE COCONUT PALM IN COLOMBIA.

The presence of coconut palms in the interior of Colombia, as reported by Humboldt and more recent writers, was also recorded by Cieza de Leon, who accompanied the first overland expedition through Colombia. Cieza de Leon came to America in 1532 as a boy of 14, and after passing in military camps and marauding explorations the years that lads usually spend in school he began, at the age of 22, the writing of a history, "because others of more learning were too much occupied in the wars to write." Nevertheless, the writings of Cieza give us a clearer picture of the condition of the country and the people than do those of any of the learned historians

^a Cassava and Indian corn, capsicum, peanuts, alligator pears, pineapples, and doubtless other American plants, including American types of cotton, appear to have been introduced into West Africa by the Portuguese at very early dates, and are now widely distributed in that continent. The coconut has remained of little importance in Africa, not being utilized as a source of oil, that of the oil palm (*Elaeis*) being of better quality and more easily obtainable.

^b "The inhabitants [of Cape Palmas] believe, that whoever plants a Cocoa-palm will die, before it produces fruit (i. e., in about seven years). The Chief of the fishermen yielded at last to the entreaties of the American Governor, and put some Cocoa-nuts on the ground: he then drove cattle over the spot, that he might not incur the consequences of planting and covering them with earth!"—Hooker, W. J., *Niger Flora*, p. 37. (London, 1849.)

like Oviedo, Acosta, and Hernandez, and merit the high commendations bestowed by Clements R. Markham, who translated Cieza's writings.^a

The statement of Cieza de Leon regarding coconuts is as follows:

. . . The site is twenty-three leagues from the city of Cartago, twelve from the town of Anzerma, and one from the great river, on a plain between two small rivers, and is surrounded by great palm trees, which are different from those I have already described, though more useful, for very savoury *palmitos* are taken from them, and their fruit is also savoury, for when it is broken with stones, milk flows out, and they even make a kind of cream and butter from it, which they use for lighting lamps. I have seen that which I now relate, and it all comes within my own experience. The site of this town is considered rather unhealthy, but the land is very fertile.^b

Velasco, in writing of the palms of the same region over two hundred years later, identifies Cieza's reference and applies it to the variety of coconut called *vira chonta* or "butter palm." It may be doubted whether this is the true coconut palm or a distinct species which has been called *Cocos butyracea*.

To treat *butyracea* as a distinct species does not render it any less interesting, either from the botanical or the agricultural side. If the interior of Colombia affords other species of *Cocos* that are distinct from *Cocos nucifera* and yet closely related to it the question of origin will be still more definitely answered, and the diversity of types available for introduction to other parts of the world will appear still greater. It is evident, however, that Velasco considered his *vira chonta* only as a variety of the coconut palm, since he includes it with three other varieties. Velasco's account of the coconut palms of Colombia, written about 1789, but not published till 1844, appears to contain more original information than any other statement on the subject. It is evident that he took special interest in the palms as a group, since he describes numerous species in detail, with their native names and uses. The parts relating to the coconut palms may be translated as follows:

There are more than fifty different species of palms, all with the generic name *Chonta*. . . . The fruit, in the language of Peru is called *ruru* and in that of Quito *lulum*, which means *egg*; accordingly the fruit of any sort of palm is called *chontaruro*.

^a "The work of Pedro de Cieza de Leon is, in many respects, one of the most remarkable literary productions of the age of Spanish conquest in America. Written by a man who had passed his life in the camp from early boyhood, it is conceived on a plan which would have done credit to the most thoughtful scholar, and is executed with care, judgment, and fidelity. . . . In arrangement, in trustworthiness, in accuracy, and in the value of his observations, the work of Cieza de Leon stands higher than that of any contemporary chronicler: and these qualities in his book are enhanced by the romantic life and noble disposition of its author."—The Travels of Pedro de Cieza de Leon, trans. by C. R. Markham, pp. i, lvii of the introduction. (Hakluyt Society, 1864.)

^b Op. cit., p. 68.

Hatun chonta, that is, the largest of all palms. Its nut (*coco*) is commonly as large as the head of a man, covered with a tow which is the best kind for gun wads. The white marrow is very good, thick as a finger, and from it, by pressure, is extracted a very rich and sweet oil. The milky liquid is also sweet, refreshing, and good to drink, and from the nuts are made large vessels to hold liquors and for other purposes.

Suni chonta is the palm with the long nut, slightly smaller than the preceding. It has the same properties and the tree is a little smaller.

Vira chonta, the palm with buttery fruit. It is as high as the preceding, but much more slender and with narrow leaves. The fruit is somewhat smaller, almost spherical, with little or no firm marrow, and the milk so thick that after a little beating it coagulates into a very rich butter for eating or lighting. It is peculiar to the River Cauca, on the confines of the province of Popayan, where the Spaniards first discovered it in 1545, one of them, the historian Chieca de Leon, describing it. It is thus seen how lightly a thousand falsehoods are written by some, like Francisco Hernandez, native of Mexico, who in his Latin history asserts that *cocos* were brought by the Spaniards from the East Indies to the West. At their first entrance into South America they found very old palms full of fruit, which never occurs until after the age of 16-20 years with these large kinds of *cocos*.

Yurac chonta, the palm which yields the white *coco*, not only the marrow but all the shell being white, and this, being very thick, is made into cups for chocolate with embossed work. The meat is not very good and the tree rather small. * * *

Almost all of these palms are from the province of Maynas, and some of them from Guayaquil and Popayan.^a

Velasco does not give any definite citation of the books of Hernandez, and may not have known them at first hand. In reality, Hernandez does not seem to have said that coconuts were brought from the East Indies. He states that coconuts were not found in New Spain (Mexico), but he reports at the same time that they were abundant in the West Indies as well as in the East, so that the idea of an introduction by the Spaniards is rather denied than affirmed.

Velasco's reference to the use of the small shells of the *yurac chonta* for embossed work may have interest in connection with the photograph of the carved shell of a small coconut shown in plate 53, figure 1. The specimen from which this photograph was taken was presented to the writer, some years ago by Gen. E. A. Lever, of New Orleans, having been found by him in a grave in the Chiriqui district of Panama in digging for the gold ornaments and pottery that are often found in the prehistoric graves of that region.

ECONOMIC STATUS OF THE COCONUT IN TROPICAL AMERICA.

While the early records appear sufficient to establish the existence of the palm in the New World at the time of the early discoveries, they certainly do not indicate that it was a food plant of primary importance in any part of tropical America, unless it were along the Pacific coast of Panama and Costa Rica. If the coconut had had any such prominence among the Caribs and Arawacks of the West Indies as among the Polynesians and Malays of the East it is incredible

^a Velasco, J., *Historia del Reino de Quito*, vol. 1, pp. 52-54. (Quito, 1844.)

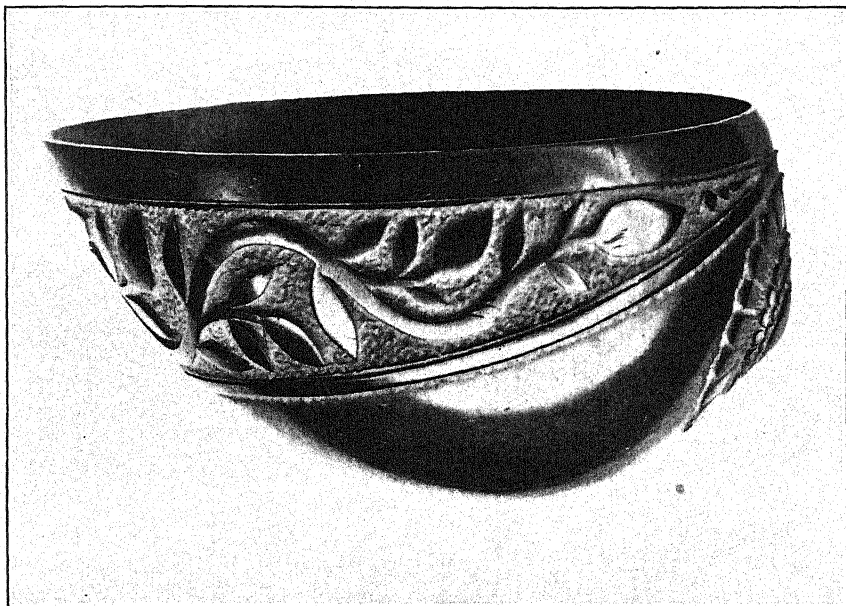


FIG. 1.—CARVED COCONUT SHELL.

From a grave in the Chiriqui district of Panama. (Natural size.)

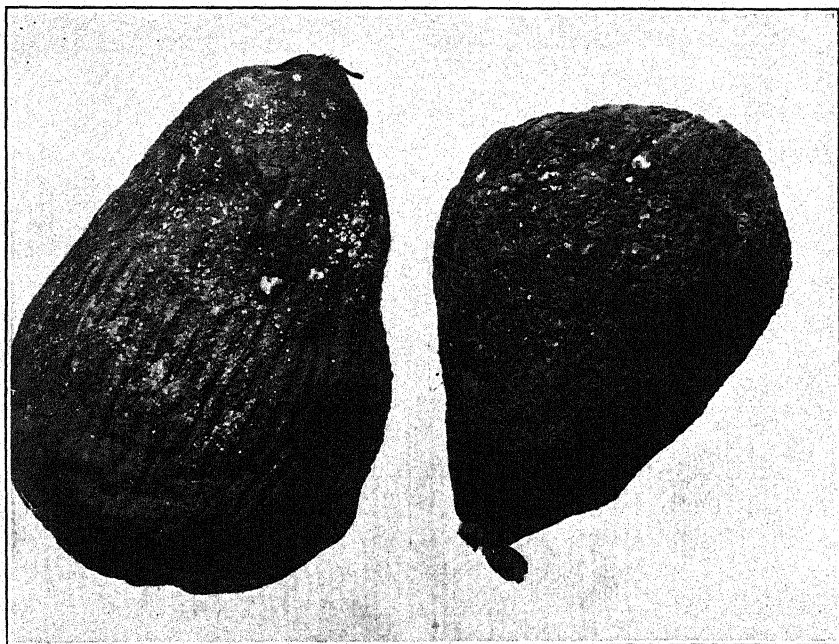


FIG. 2.—DRIED COTYLEDONS OF COCONUTS.

Brought by Dr. Edward Palmer from the region of Acapulco, where they are called 'coconut apples' (manzanas de coco) (Natural size.)

that we should not have had much more numerous and extended reports of it during the period of discovery. The lack of more adequate accounts does not appear so surprising if we consider that even at the present day the coconut is not an economic plant of the first rank in tropical America; that is, it is nowhere of such cardinal importance as in the tropical islands of the Pacific.

Outside of a few districts where commercial plantations of coconuts have been established, the status of the coconut among the natives of tropical America remains to-day much the same as it appears to have been at the time of the discovery of America by Europeans. Coconut palms are found on all the coasts and principal islands, planted more or less abundantly as the inhabitants of the different regions happen to be more or less civilized.

People too backward in civilization to have settled abodes do not undertake the cultivation of long-lived tree crops like the coconut. The more primitive tribes of Indians either have no agriculture at all, or a merely nomadic form of agriculture that utilizes only annual or quick-growing crops, which are planted every year in new clearings instead of upon the same stationary farm as in the temperate regions. A reason for this nomadic system of agriculture that generally prevails in forested tropical regions of low elevation is found in the fact that it is much easier to clear a new tract of land every year by cutting and burning than to pull up the weeds that invade cleared land or to maintain the fertility of the soil under continued clearing and cropping. It is only when people have reached the next stage of agricultural development and maintain permanent clearings and gardens, as among the Polynesian and Malayan inhabitants of the islands of the Pacific and Indian oceans, that the coconut and other tree fruits become regular, staple products. Elsewhere, as among the tropical Indians of America and the natives of Africa, the coconut remains only secondary and exceptional, planted occasionally in the larger villages or towns that happen to be located near the coast, but nowhere attaining any serious or indispensable importance.

At the present time the progress of the West Indian coconut industry, if not the actual existence of the palm in this region, appears to be threatened by a serious disease, which enters the terminal bud and kills the palm. Investigations of this disease indicate that it is due to a bacterial parasite, which appears to be spreading very rapidly.^a

^a Horne, W. T., *La Enfermedad de los Cocoteros*, Boletín Oficial de la Secretaría de Agricultura, Industria y Comercio, vol. 3, p. 1. (1907.) *The Bud Rot and Some other Coconut Troubles in Cuba*, Bull. 15, Estación Central Agronómica de Cuba. (1908.)

Johnston, J. R., *The bud rot of the coconut palm*, U. S. Department of Agriculture, Bureau of Plant Industry, Circular 36. (1909.)

The meat of the ripe nut, for which coconuts are imported into temperate countries, is not the part most valued in the tropics, but the "milk" of the unripe nut. On many of the coral islands of the Pacific, where there are no springs or other supplies of water, the natives could not survive without the milk of the coconut. In Porto Rico and elsewhere in America the coconut is also valued chiefly as the source of a beverage, but where fresh water is as abundant as in the West Indies the milk of the coconut is a luxury rather than a necessity. The unripe nuts are carried to the towns and sold as a beverage, like lemonade or soda water in temperate regions.

The meat of the coconut has little more importance in the American tropics than in the United States, being used mostly for pastry and confectionary, and not as a staple article of diet. Even the oil of the coconut which serves so many culinary and other domestic purposes in the East Indies is almost unknown in the American tropics. The extraction of the oil and its use in cooking are said to be practiced in British Honduras and in Trinidad, but by European residents rather than by the natives of the country. There are no such multitudinous applications of the shells, husks, fibers, leaves, sap, and all other parts of the palm as in the East Indies.

On the west coast of Mexico, according to Dr. Edward Palmer, use is made of the so-called "coconut apple" (*manzana de coco*), in reality the swollen cotyledon of the germinating nut. The cotyledon gradually absorbs the food materials stored in the meat of the nut, at the same time increasing in size till it fills the whole cavity of the shell. The fleshy part of the cotyledon is said to have a pleasant, sweetish taste, and to be much more delicate and more readily digestible than the meat itself. The coconut "apples" are also dried and are sold in the native markets in this condition. Plate 53, figure 2, shows a photograph of two dried cotyledons of the coconut. There is nothing to show whether the use of the cotyledon represents a native custom in Mexico or was imported from the Pacific Islands, where it also exists. The making of fermented drink called "tuba" from the sap of the palm appears to have been introduced into the vicinity of Acapulco from the Philippines, as indicated by the presence of the Filipino names.

An additional reason why the culture of the coconut palm was not flourishing in the West Indies at the time of the discovery is found in a fact of history. Columbus and other early explorers made repeated statements to the effect that the inhabitants of the islands were everywhere at war with the Caribs, the seafaring cannibals who preyed upon the more peaceable agricultural natives of the islands. The fear of the Caribs kept the natives from living near the coasts.

Even when the lands along the coast were extensively cultivated, as described by Columbus in Hayti, it was difficult to find people or houses.^a One of Peter Martyr's letters to the Pope gives an account of the Caribs and reflects the impression of the early explorers regarding the havoc wrought by them in the West Indies.

Theyr common meate, is *Ages*, *Iucca*, *Maizium*, *Battata*, with suche other rootes and frutes of trees, and also suche fysshe as they vse in the Ilandes and other regions of these prouinces. They eate mans fleshe but seldome, bycause they meete not oftentymes with strangers, except they goo forth of theyr owne dominions with a mayne armye of purpose to hunt for men, when theyr rauenyng appetite pricketh them forwarde. For they absteyne from them selues, and eate none but suche as they take in the warres or otherwyse by chaunce. But suerly it is a miserable thyng to heare howe many myriades of men these fylthy and vnnaturall deuourers of mans flesshe haue consumed, and lefte thousandes of moste fayre and frutfull Ilandes and regions desolate withowte menne: By reason wherof owre men founde so many Ilandes whiche for theyr fayrenes and frutefulness myght seeme to bee certeyne earthly Paradysses, and yet were vtterly voyde of men. Hereby yowre holynesse may consider howe pernicious a kynde of men this is.^b

With such enemies to pounce upon them from the sea it is easy to understand that the coconut palm could not be popular among the coast-dwelling natives of the West Indies after the Carib invasions began. To plant coconut palms, or even to allow them to grow where they could be seen from the sea, would only invite the attacks of the cannibals by showing them where their human prey could be found.

THE PALMS OF COCOS ISLAND.

Another piece of definite evidence regarding the habits and history of the coco palm comes from a small island in the Pacific Ocean about 300 miles to the west of Panama. The name Cocos Island was given by the early navigators because of the abundance of coconut palms found on it. Since the coming of the Spaniards, however, the island has not been inhabited and the coconut palms have almost completely disappeared. Prof. H. Pittier, who visited Cocos Island in May, 1898, and again in February, 1902, in the interest of the Costa Rican Government, reports that the palms that now abound on Cocos Island are not coconut palms, but belong to the genus *Euterpe*. Some of the American palms that have been referred to *Euterpe* have a superficial resemblance to coconut palms,

^a He believed that the villages must be at a distance from the sea, whither they went when the ships arrived; for they all took to flight, taking everything with them, and they made smoke-signals, like a people at war.—The Journal of Columbus, trans. by C. R. Markham, p. 104, Hakluyt Society, 1893.

^b Martire in Arber, op. cit., p. 159. (See footnote, p. 276, above.)

but they belong in reality to a distinct group, much more related to the Cuban royal palm than to the coconut.^a

Excepting a few planted very recently by a treasure seeker living on the island, the only coconut palms found by Professor Pittier were a small cluster near the southwestern end, on a beach so protected by rocks and breakers that landing from the sea is quite impracticable. The mountains visible from the anchorages at the other end of the island are clothed with the Euterpe palms, not with coconut palms. The treasure seeker had brought coconuts from Puntarenas, Costa Rica, and planted them at Wafer Bay, but these were found to be different from those already growing on the island. Some of the latter had also been planted recently at Chatham Bay.

De Candolle refers to Dampier as having found an abundance of coco palms on Cocos Island and looks on their presence on an uninhabited island so close to the American continent as an additional reason for believing that the shores of the New World might have been stocked by sea-borne nuts from the archipelagoes of the Pacific. It has been shown in the previous paper that Dampier did not visit this Cocos Island, and that the "island of cocos" to which Dampier referred was near the coast of Colombia. It was not, as De Candolle supposed, the Cocos Island of modern maps.^b

From the preceding facts it might be inferred that Cocos Island had been misnamed as a result of mistaking the Euterpe palms for coconuts, but there is historical evidence to justify the name. Although Dampier, as before stated, did not visit Cocos Island, we have an authentic account by Wafer of the existence of large numbers of coconuts on this island in 1685. Wafer was at one time Dampier's first officer, and his "Travels" are often bound with Dampier's "Voyages." This may explain De Candolle's citation of Dampier's statement as applying to the modern Cocos Island. Though Wafer was not a botanist, his account of the coconuts of Cocos Island is too circumstantial to permit us to doubt that coconuts existed in abundance in his day.

Our men being tolerably well recover'd, we stood away [from the Gulph of Amapalla] to the Southward, and came to the Island *Cocos*, in 5 Deg. 15 Min. N. Lat. 'Tis so called from its Coco-Nuts, wherewith 'tis plentifully stor'd. 'Tis but a small Island, yet a very pleasant one: For the Middle of the Island is a steep Hill, surrounded all about with a Plain, declining to the Sea. This Plain, and particularly

^a The resemblance lies in the shape and position of the leaves when seen at a little distance. The crown of leaves of the royal palm does not resemble that of the coconut, because the leaflets are inserted at different angles along the midrib, but this is not the case in the Porto Rico mountain palm (*Acrista monticola*) nor in the still more graceful *ternera* or *halaute* (*Plectis oventiana*) that adorns the summits of many limestone mountains in eastern Guatemala.

^b Contributions from the U. S. National Herbarium, vol. 7, pp. 264, 265. (1901.)

the Valley where you go ashore, is thick set with Coco-nut Trees, which flourish here very finely, it being a rich and fruitful Soil. They grow also on the Skirts of the Hilly Ground in the Middle of the Isle, and scattereing in Spots upon the Sides of it, very pleasantly.^a

So much for the number and location of the palms. That this description does not, by any chance, apply to any other palm with which the coconut could be confused, even in the seventeenth century, is shown by a further incident.

Nor did we spare the Coco-Nuts, eating what we would, and drinking the Milk, and carrying several Hundreds of them on board. Some or other of our Men went ashore every Day: And one Day among the rest, being minded to make themselves very merry, they went ashore and cut down a great many Coco-trees; from which they gather'd the Fruit, and drew about 20 Gallons of the Milk. Then they all sat down and drank Healths to the King and Queen, etc. They drank an excessive Quantity; yet it did not end in Drunkenness: But however, that Sort of Liquor had so chilled and benumb'd their Nerves, that they could neither go nor stand: Nor could they return on board the Ship, without the Help of those who had not been Partakers in the Frolick: Nor did they recover it under 4 or 5 Days Time.^a

In view of these statements the present complete, or nearly complete, extinction of the coco palm can scarcely be understood except as the result of the absence of human inhabitants from Cocos Island during the last two centuries, another example of the fact that the species can not compete with the vegetation of the coasts and islands of the humid tropics. If Cocos Island were a mere coral atoll or sand bar, the traditional possibility of sea-drifted coconuts could still be drawn upon, but it has an area of about 18 square miles and a mountainous surface, the highest peak rising about 660 meters. When the size and topography of the island are considered and the presence of a considerable native flora, Wafer's statements regarding the coconut groves on the slopes away from the sea would seem to point to clearing and planting by the hand of man though the apparent number of the palms may have been increased by confusion with the native species that grows on the mountains.

That there were no inhabitants at the time of Wafer's visit does not prove that the island had never been occupied. Even without a permanent population the coconuts may have been planted and cared for by natives of the mainland for use during fishing expeditions, a plan followed in some localities in the Malay region. The serious disturbances that followed the arrival of the Spaniards in the Panama region would naturally tend to interrupt such visits. Already in Wafer's time the palms must have been abandoned long enough to conceal the evidences of human agency in planting them, for any more direct indications that the island had been inhabited would undoubtedly have been noted.

^a Wafer's *New Voyage and Description of the Isthmus of America*, in Dampier's *Voyage*, vol. 3, pp. 379, 380. (London, 1729.)

One of the coconuts brought back by Professor Pittier from Cocos Island proved to be quite unlike the varieties grown in Costa Rica. It was less than half the size of the mainland coconuts and was nearly round, measuring 11 centimeters long by 11.5 centimeters wide. The "eyes" were unusually large, the fertile foramen measuring 1.8 centimeters across. We can hardly hope to learn whether the single cluster of small-fruited coconut palms found by Professor Pittier represented the last survivors of the multitude found by Wafer. Whether we take this view or assume that they were brought by some unknown expedition or were drifted in from the sea and planted by accident, as coconuts have been supposed to be, the fact remains that no coconut palms survived in the parts of the island that Wafer visited and described.

The island suffered from a plague of rats at the time of Professor Pittier's visit, and he suggests that these animals might have been responsible for the disappearance of the coconut palms. It is true that rats often do serious damage in plantations, making it necessary to belt the palms with tin to keep the pests from climbing up. But if the extinction of the palms is to be ascribed to the rats, they must be considered as a very general factor, since they are distributed over the whole tropical belt where coconuts are cultivated, from Porto Rico to the islands of the Pacific and Indian Oceans. They would be as likely to interfere with the perpetuation of coconuts in any abandoned place as on Cocos Island.

Ethnologists may find in this hitherto unsuspected primitive occupation of Cocos Island an additional evidence of the maritime skill of the Indians of the Pacific coast of tropical America, and thus be the more willing to consider the possibility of prehistoric communication between the shores of the American Continent and the Pacific islands. The accounts which the Peruvians gave to the Spaniards of lands in the Pacific led to the fitting out of the expeditions of Mendaña, Sarmiento, and Quiros. The Polynesians also had traditions of places farther east than any existing islands. The natives of the Marquesas Archipelago, the group that lies nearest to Cocos Island and the Isthmus of Panama, told Captain Porter that the coconut was brought from another island to the eastward.

The cocoa-nut tree, as I before remarked, was said to have been brought from Ootoopoo, an island which is supposed by the natives to be situated somewhere to the windward of La Magdalena.

None of our navigators have yet discovered an island of that name, so situated; but in examining the chart of *Tupia*, that native of the island of *Ulitea* who left there with Captain Cook on his first voyage, we find nearly in the place assigned by the native of *Nooaheevah* to *Ootoopoo* an island called *Ootoo*.^a

^a Porter, D., Journal of a Cruise made to the Pacific Ocean, vol. 2, p. 139. (Philadelphia, 1815.)

Porter notes the further fact that a native of the Society Islands had given to Captain Cook, fifty years before, a similar name for an island supposed to be located to the eastward of the Marquesas group. Like other Polynesians, the natives of this archipelago were accustomed to sail away with their families in large canoes well provisioned with food and with cuttings of their cultivated plants, to discover and colonize new islands. An Englishman, who had lived in the Marquesas for several years, informed Porter that he had known of the departure of more than 800 people who left "in search of other lands," never to return.

As an indication that some of these expeditions from Polynesia reached the American Continent we may refer to the presence of the banana, a plant certainly native of the Old World, and also widely distributed in pre-Spanish America. Balboa found, on his first expedition across the Isthmus of Panama, a tribe of dark-skinned, heavily tattooed people with frizzled hair, which various historians have described as negroes, following a statement to that effect by Peter Martyr.

There is a region not past two dayes iourney distant from *Quarequa*, in which they founde only blacke Moores: and those excedynge fierce and cruell. They suppose that in tyme paste certeyne blacke mores sayled thether owt of *Aethiopia* to robbe: and that by shippewracke or sume other chaunce, they were dryuen to those mountaynes.^a

Oviedo's much more detailed account of these people makes it apparent that they were not negroes. Peter Martyr's statement is in the nature of a casual report echoed from second-hand information. Oviedo's narrative was drawn up on the Isthmus where he arrived in 1513, the year after Balboa crossed. It embodies the direct testimony of Balboa himself and other eyewitnesses of the events of his remarkable expedition.^b

It is evident enough from Oviedo's account that the black frizzle-haired people encountered by Balboa were recent intruders and not ordinary Indians, but there is not the slightest indication, expressed or implied, that they were African negroes, who were quite unable to make voyages to America, either by design or by accident. The Kroos and other maritime tribes of West Africa use only small canoes and make only short voyages along the coast, usually going ashore to sleep. The Pacific, however, was the scene of a general

^a Martire in Arber, op. cit., p. 139. (See footnote, p. 276.)

^b Oviedo, *Historia General y Natural de las Indias*, vol. 3, pp. 8, 126-129. (Madrid, 1851: see above, p. 278.) The reason why the facts given in this most extensive of the early histories of America have not received more general consideration is doubtless to be found in the fact that the work, though written in the early part of the sixteenth century, was not published until the middle of the nineteenth, except in the form of short extracts and abridgements, which gave small indication of the detailed circumstantial character of much of the information.

maritime activity, as shown not only by the Polynesians, but by the dark, frizzle-haired Melanesian people who were extending themselves to the eastward and had reached not only to Fiji and Tonga, but to Tahiti ^a and the Marquesas. ^b

The place where these frizzle-haired people were found by Balboa was close to the Pacific Ocean and very far from the Atlantic. Nor is it entirely impossible that additional present-day evidence is still to be obtained by careful ethnological study of the Panama region, where a rather peculiar clan of frizzle-haired, seafaring people still exists, locally called Chiricanos. They are commonly supposed to represent an intermixture of negroes and Indians, but are worthy of study as a possible remnant of Polynesian influence.

The period in which the coconut was first carried westward across the Pacific was, in all probability, so extremely remote that shore lines and land masses may easily have been different from what they are now. Other low-lying islands between Cocos and the Marquesas group may have disappeared, but the biological and historical facts do not leave us dependent on such speculations for an assurance of human contacts between the Pacific islands and the coasts of tropical America. It becomes obvious that the possibility of communication with the islands of the Pacific may have continued nearly to the time of the coming of the Spaniards, and that not by ocean currents or shipwrecks, but by deliberate voyages of maritime people, whose other exploits in the Pacific show that they were quite capable of carrying the coconut into the Pacific, and, many generations later, of bringing the banana back.

THE COCONUT PALM UNABLE TO MAINTAIN ITSELF ON SEACOASTS.

The disappearance of the coconut palms from Cocos Island is a striking example of the general fact that the coconut palm is not only unable to establish itself on seacoasts, but is unable to persist after it has been planted. The greater the emphasis laid upon the idea that the coconut can float, and can be cast up and grow on the beach, the greater appears the discrepancy between the theory of maritime distribution and the actual facts, for the palm is not known to exist except as a cultivated plant in the care of agricultural people.

That nuts are sometimes carried for long distances by the sea there can be no doubt; everything is carried that has a sufficiently low specific gravity. A striking instance of this kind has been

^a Bougainville, *A Voyage Round the World (1766-1769)*, trans. by John Forster, p. 249. (London, 1772.)

^b Quiros (1595), in Dalrymple, *Historical Collection of Voyages and Discoveries*, vol. 1, p. 69. (London, 1770.)

personally communicated by Dr. W. E. Inksetter, of Alajuela, Costa Rica. A coconut, with the husk intact, was found on the beach in the island of Ronsay, in the Orkney group, to the north of Scotland, in the winter of 1892-93. Doctor Inksetter saw the nut and drank some of the milk, which was still in good condition.

But of what advantage is such transportation if the nut encounters unfavorable conditions when it lands, and thus fails to germinate or to grow to maturity and establish its seedlings in turn? We should find on some tropical coast a place where the palms thrive and multiply, where we find old palms surrounded by flourishing young ones, growing spontaneously, without the aid of man, but no such instance has been reported. Instances of floating nuts or of supposedly self-sown palms indicate the opposite of what they are sometimes thought to prove, for the failure of the palms to persist is only emphasized by showing that opportunities have been ample. There seems to be no authentic record of coco palms establishing and maintaining themselves on any tropical coast in a wild or truly spontaneous condition. A palm that is unable to maintain itself on the land has nothing to gain by having its nuts drifted about by the sea.

The complete absence of coconuts from the extensive tropical coast line of Australia until planted by European colonists has already been cited as a gigantic experiment showing that the coconut did not establish itself without human help, even in a place where it afterwards thrived in cultivation. It is known that the shores of Australia were visited yearly by many Malay fishing boats carrying large quantities of coconuts among their food supplies. Many nuts have also been found cast up on the tropical beach of Australia. The palms exist in large numbers on small islands in the Torres Straits, only 30 or 40 miles from the Australian coast. The contrast between these palm-covered islands and the palmless shores of Australia has made a strong impression upon eyewitnesses.

Murray Island is about 700 feet high at its highest point, and consists of steep broken ground. Its whole aspect is singularly different from any part of Australia, since the whole of its lower portion, and a good part even of the hills, is covered by a continuous grove of cocoa-nut trees. The entire absence of these trees from every part of Australia is a most striking fact, since it is, I believe, the only country in the world so much of which lies within the Tropics in which they have never been found. We had once or twice found cocoa-nuts on the beach, still more or less fresh; and here is an island, absolutely within the Great Barrier reef, completely covered by them, and yet neither by Flinders, King, Wickham, Stokes, or ourselves have any trees been discovered anywhere upon the mainland. We could perceive many natives on the beach of Murray Island, as also a nearly continuous line of large dome-shaped

huts, surrounded by fences of tall poles ornamented by large shells; everything shewing the natives to be a different race of beings from the Australians.^a

The explanation of the absence of coconuts in Australia has been found by all travelers in the fact that the Australian natives differ from those of all the Pacific islands in being nonagricultural. The same is true of another peculiar and very primitive people living on the Andaman Islands of the Indian Ocean. With them also the coconut palm was lacking, though their islands lie in the midst of the East Indies, where the coconut and its numerous varieties have been supposed to originate and distribute themselves by sea.^b

No other inhabited tropical coasts and islands of the Pacific and Indian oceans appear to be without coco palms, but no other peoples failed to plant and care for them. Throughout this region there is no difference of popular opinion regarding the strict dependence of the coconut upon man. The idea of wild coconuts planting themselves on tropical seacoasts is strictly the product of the imagination of authors who have written books about the Tropics without visiting such regions, or at least without taking into account the opinions of those who have first-hand familiarity with the habits of the palm.

Throughout the South Sea islands coco-nut palms abound, and oil may be obtained in various places. Some of the uninhabited islands are covered with dense groves, and the ungathered nuts, which have fallen year after year, lie upon the ground in incredible quantities. Two or three men, provided with the necessary apparatus for pressing out the oil, will, in the course of a week or two, obtain enough to load one of the large sea canoes. . . .

The coco-nut is essentially a maritime plant, and is always one of the first to make its appearance on coral and other new islands in tropical seas, the nut being floated to them, and rather benefiting than otherwise by its immersion in the salt water.^c

The authority of Simmonds might seem to give weight to these statements, but no such ideas are found in the account of the coconut palm in that author's subsequent manual of Tropical Agriculture. The islands where the coconuts established themselves and accumulated in "incredible quantities" were never specified.^d

^a Jukes, *Voyage of the Fly to the Eastern Archipelago*, 1842, vol. 1, p. 132. (London, 1847.)

^b It is interesting to note that with the exception of a few spots, evidently planted by the early colonists, cocoa-nuts do not occur in the Andamans, and this is especially remarkable from the fact that the conditions are favorable for their propagation.—Safford, W. E., *The Abbott Collection from the Andaman Islands*, Smithsonian Institution, Ann. Rep., 1901, pp. 477-492. (1902.)

^c Simmonds, P. L., *The Commercial Products of the Vegetable Kingdom*, pp. 549, 550. (London, 1854.)

^d If anything further is needed to show that Simmonds had no direct knowledge of the coconut palm when the earlier work was written, his fanciful statement regarding the germination and growth of the palms will certainly suffice. Almost every line contains a fresh error.

"The coco-nut is usually planted as follows:—Selecting a suitable place, you drop into the ground a fully ripe nut, and leave it. In a few days a thin lance-like shoot

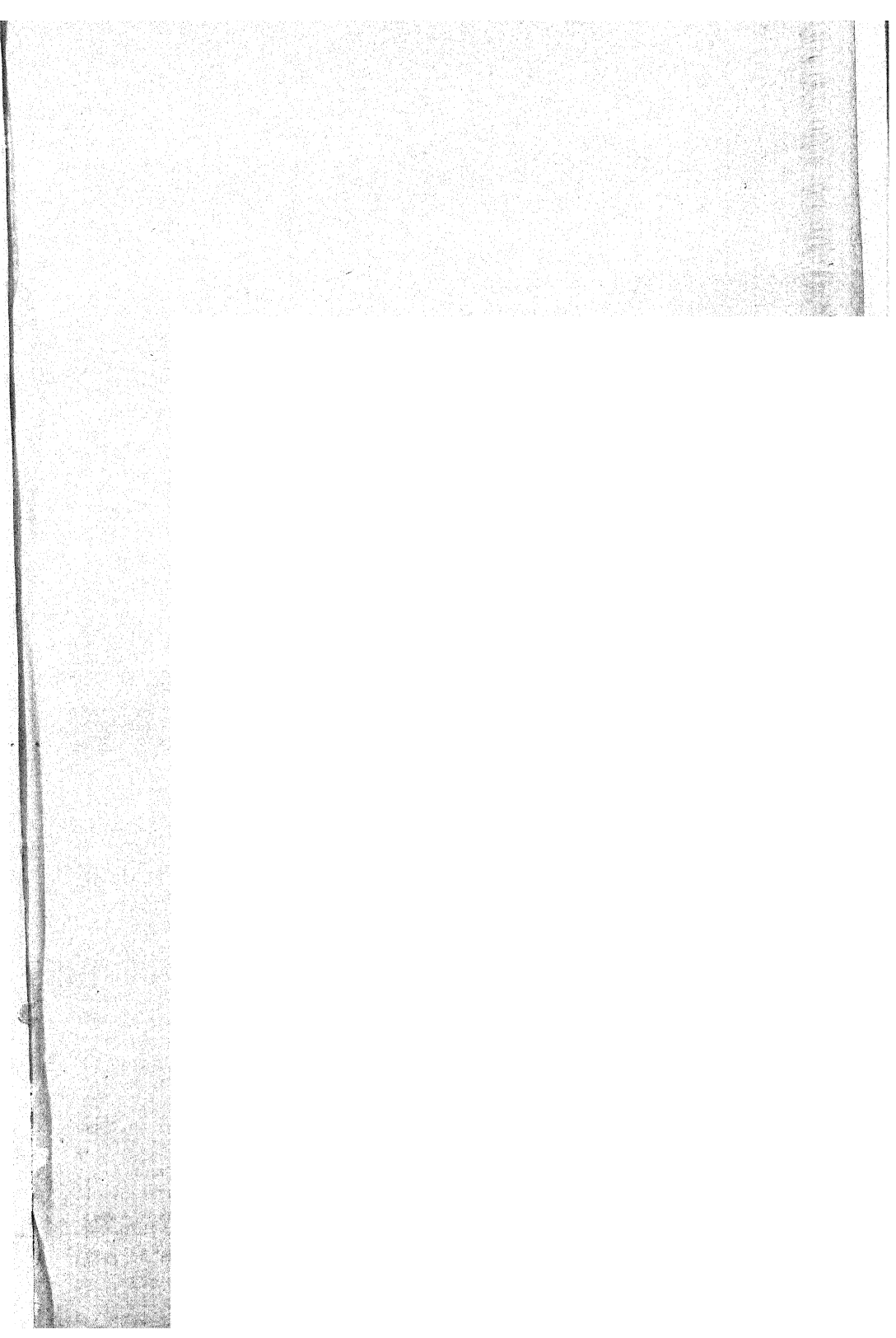




FIG. 1.—COCONUT PALMS OVERHANGING THE SURF AT HIGH TIDE, PUERTO BARRIOS, GUATEMALA.



FIG. 2.—COCONUT PALMS OVERHANGING THE SEA, LIVINGSTON, GUATEMALA.
The trunks lean very strongly toward the sea as a result of competition with other vegetation.

The conclusions of those who have considered the subject from the tropical standpoint and with the advantage of actual contact with tropical conditions, have been canvassed in the previous paper, but a few of their statements may be repeated. Pickering testifies:

... *C. nucifera* throughout the Pacific occurs only on those islands to which it has been carried by the natives, a fact well known to traders; was observed by myself only under cultivation throughout the islands of the Pacific and the Malayan Archipelago.^a

... So invariably is its presence attributable to human operations that it has become a guide to the traders in seeking for natives.

Notwithstanding that the fruit is well adapted for floating uninjured over a wide expanse, I have never met with an instance of a cocoa palm having spontaneously extended itself from island to island.^b

Other testimonies are the following:

... It is to be emphasized that all coconuts are *planted*; the idea of a wild palm being as strange in Funafuti as that of a wild peach might be in England. ... I doubt whether, despite popular opinion to the contrary, a wild coconut palm is to be found throughout the breadth of the Pacific.^c

... From repeated observation, [in the Solomon group] I am convinced that the coco-nut palms will rarely grow, and certainly will not bear fruit, unless attended to and kept clear of overgrowing trees.^d

... The Cingalese have a saying that Cocoa-nut trees do not thrive unless "you walk and talk among them," indicating that trees thrive the best when carefully attended to.^e

THE COCONUT PALM NOT TOLERANT OF SHADE.

When the traveler who lands for the first time on a tropical coast looks up along the shore and sees the coconut palms leaning out toward the strand or actually overhanging the water, he is at once reminded of and confirmed in the idea of maritime distribution. (Pl. 54, figs. 1 and 2.) But if he looks further into the facts he will learn

forces itself through a minute hole in the shell, pierces the husk, and soon unfolds three pale-green leaves in the air, while, originating in the same soft white sponge which now completely fills the nut, a pair of fibrous roots pushing away the stoppers which close two holes in an opposite direction, penetrate the shell, and strike vertically into the ground. A day or two more, and the shell and husk, which in the last and germinating stage of the nut are so hard that a knife will scarcely make any impression, spontaneously burst by some force within; and, henceforth, the hardy young plant thrives apace, and needing no culture, pruning, or attention of any sort, rapidly arrives at maturity."—Simmonds, *op. cit.*, p. 555.

The rapidity of germination and growth are entirely misconceived; only one leaf is produced at a time, and the first leaves are simple, not three-parted; roots do not come out of the holes, but grow from the young plant; the shell does not burst; the young palms do not thrive without care.

^a Pickering, Charles, *Chronological History of Plants*, p. 428. (Boston, 1879.)

^b Pickering, Charles, *The Races of Men*, pp. 54, 323. (London, 1851.)

^c Hedley, *Memoir III*, Australian Museum, Sydney, p. 22. (1896.)

^d Woodford, *A Naturalist Among the Head Hunters*, p. 194. (London, 1890.)

^e Seemann, B., *Popular History of the Palms and their Allies*, p. 158. (London, 1856.)

that coconuts do not grow toward the sea in order to be able to drop their fruits into the waves, but because this side is bare to the sun. The trunks of the palms reach out toward the sea for the same reason that house plants turn toward the window. Many writers overlook this fact, but there are exceptions, as the following statement will show:

. . . We must also give up the poetic fancy that the coconut tree stretches out towards the sea because it loves the briny breeze. The truth is, that the tree is a lover of light, and will bend in any direction to reach it; and as there is no obstruction on the sea shore it naturally bends in that direction and would do the same if the open space were inland. So sensitive is it to shade of the lightest that it instinctively bends away from it, and instances may be seen where the tree has grown almost horizontally till outside the influence of the shade before it assumed its upward growth.^a

The better exposure to the sun goes far to explain the fact that coconut palms usually thrive better close to the sea. It is easier to to give coconuts the necessary exposure along the beach where the other vegetation is less luxuriant than a few rods farther back, and the beach locations where the coconuts will thrive may be of no use for any other crop. Coconuts are accordingly planted in many spots where no other evidences of agriculture appear, so that the unwary traveler has many opportunities to form conclusions which a little further investigation would dispel.

It is very natural, no doubt, to assume that the coconuts rising up from among other vegetation or overhanging the sea from the end of a promontory (pl. 54, fig. 2) are wild palms, but a moment's reflection would make it apparent that the planting of palms in such a place is necessarily the work of man. Coconuts might be stranded on a low or sloping beach, but they are not to be thrown up on high ground where the waves do not come. And if they were carried in among the other plants they could not by any possibility have survived. The other vegetation has to be cleared away when coconut palms are planted.

The possibility that a coconut might be stranded on a newly formed island and multiply in the unoccupied soil, according to the fable, may not be absolutely excluded, but we know that the monopoly would not be of long duration. The very prosperity of the palms would but assist in the gathering of more fertile soil and hasten the ascendancy of their forest-forming competitors, many of which are far better able than the coconut to establish themselves on unoccupied shores. The game would be a losing one, with extinction in prospect

^a Jardine, W., *The Cultivation of the Coconut Palm*, Tropical Agriculturist, vol. 24, p. 151. (1905.)

at the end of a few generations, even though the coconuts arrived first and succeeded in establishing themselves.^a

Many cultivated plants and weeds have escaped from gardens and adopted an independent existence in parts of the world very remote from their original home. The finding of such a species in a wild state proves that the conditions are favorable to its growth, even though it gives us no evidence regarding the original home of the species. When a plant with the prolonged, world-wide opportunities of the coconut fails anywhere to escape and become established, but remains completely dependent upon man, it seems obvious that the tropical coasts where man has planted it do not afford the ideal conditions for its existence, the conditions under which it would be likely to develop as a wild plant.

Other kinds of palms afford excellent examples of intolerance of shade, showing that this character is shared in different degrees by many members of the group. An extreme case is found in Central American fan palms of the genus *Brahea*, that usually grow on precipices of limestone rock. In forested districts these fan palms are confined to the perpendicular walls, the only situations that afford them the necessary exposure to sunlight. Most of the seeds of these palms must fall into the forests below, but young palms are found only in the crevices of the cliffs. It does not appear that even small seedlings are developed without more light than the forest conditions afford. If natural selection could have rendered the species more

^aDr. H. B. Guppy has held (Journ. Trans. Victoria Inst., vol. 24, p. 267. 1890) that the coco palm was native in the Cocos or Keeling Island of the Indian Ocean, to the southwest of Sumatra, but his account is far from convincing. He admits that the island had been visited by Malays before the advent of European settlers, and also that the crabs never permit the young palm seedlings to become established unless the nuts are well buried by the planters.

Schimper found in his extensive studies of Malayan strand floras no instance of successful self-grown coconuts. (Schimper, A. F. W., *Die indo-malayische Strandflora*, 162. 1891.) Mr. W. E. Safford reports that coconuts, along with seeds of many other plants, are frequently drifted to the sandy windward beaches of the island of Guam, but that no palms grow on this uninhabited coast.

A recent work entitled "The New Flora of the Volcanic Island of Krakatau," by Prof. A. Ernst, contains a photograph of a group of nearly a dozen coconut palms, standing well back from the strand, all of nearly the same size and at nearly equal distances. Reports of the early visits to the island did not show the presence of coconut palms, though many other plants had established themselves. An explanation of the presence of the palms away from the strand is probably to be found in the changes that have continued to take place in the topography of the new island, as indicated in the following statement:

... "It is obvious that the oldest strand-plants, which sprang from the seeds and fruits from the drift formed in the first year, have been gradually separated from the beach by a constantly increasing belt and that during this shifting of the shore-line new plant-germs were introduced with the pumice and took part in the formation of the present discontinuous strand-forest" (p. 69).

tolerant of shade the conditions would seem to be most effectively arranged for bringing this about, but very little progress appears to have been made, in spite of the most rigorous and persistent selection that could well be imagined.

Many other palms are able to germinate in places where there is not light enough to enable them to grow to maturity. The seedlings may be reckoned as shade tolerant during the early period, while they can draw upon the nourishment stored in the seed, but without access to direct light they never complete their development. Young seedlings of the Porto Rican mountain palm (*Acrista monticola*) were found in great numbers near Utuado, Porto Rico, in July, 1901, in one of the dense forests of tabonuco (*Dacryodes hexandra*) that still crown the summits of a few of the mountains of that island. The young palms grow thickly over large areas, forming almost the sole undergrowth of the forest. Yet in spite of the vast numbers of seedlings not a single adult palm could be seen. The seeds of the mountain palms are said to be brought into the forest by wild pigeons that prefer the lofty tabonuco trees for roosting places.^a

The African oil palm presents similar facts. The seedlings are tolerant of shade and very tenacious of life. They are found in vast numbers along the paths in the forests where the seeds are dropped by the natives, who commonly use the fruits as food on their journeys. But in spite of the vast numbers of seedlings, mature oil palms are never found in the forest belt, except where natives have cleared the land for rice or cassava. It is easy to understand why oil palms are much more abundant in regions that support large native populations, as in Dahomey. The more frequently the land is cleared the greater the advantage of the oil palms over other forms of vegetation.

In their relation to external conditions the whole natural order of the palms can be divided into two distinct series, those that are tolerant of shade and those that are not. Many species of small palms live as undergrowth in the shaded depths of tropical forests, and are, in nature, strictly confined to such situations. The forests of tropical America afford numerous examples of undergrowth palms among the species of *Chamaedorea*, *Geonoma*, and related genera. All of the large palms, those that attain the dimensions of trees, require exposure to the sunlight in order to complete their development.

The palms may have been more prosperous in some former geologic time, but the competition of more modern and efficient types of vegetation now confines them to situations relatively unfavorable for

^aThe Porto Rican mountain palm was described as a new genus in 1901. (O. F. Cook, A synopsis of the palms of Porto Rico, Bulletin of the Torrey Botanical Club, vol. 28, p. 555.) For a photograph of the tabonuco forest in which the seedling palms occur, see Cook, O. F., and Collins, G. N., Economic Plants of Porto Rico, Contributions U. S. National Herbarium, vol. 8, p. 132, pl. 34. (1903.)

other plants, where special conditions enable the palms to persist. Some of the North American palms that require sunlight have taken refuge in deserts of Mexico, while others are confined to the fire-swept pine barrens of Florida. A third series, represented by *Thrinax* and allied genera, occupies the exposed precipices and crags of the dry limestone hills and keys of the West Indies. A fourth series is limited to swamps or river banks (*Augustinea*), and a fifth to high mountain summits (*Acrista*). With the exceptions of the undergrowth palms and the slender rattans and similar climbing types, there are very few true forest species able to secure a footing or even to hold their own in undisturbed tropical tree growth.

These limitations are shared by the coconut and all of its nearer relatives, which inhabit relatively open interior districts, rocky mountain slopes, and barren or exposed situations where vegetation of other types is comparatively sparse. Some of the species frequent river banks, but these are distant and rather degenerate cousins of the coconut. Few members of the family, if any, are natives of truly maritime districts. Very few palms, even of other families, are to be reckoned as definitely maritime plants, for while several frequent the seashore, such as the palmettos of Florida and the West Indies, they are also able to grow away from the sea. A species of *Phoenix* (possibly *P. reclinata*), native in Liberia, is confined to the sea beach, occurring only in the outermost zone of shrubby vegetation stunted by the salt spray, but this apparent preference is likely to be due to the fact that the sea beach affords more of the necessary exposure to the sun than can be obtained in the adjacent forest.

For the want of a more distinctive term, the larger palms are called "trees," but they might be described more correctly as overgrown herbs. Their trunks are always constructed on the same general plan as the cornstalk or the sugar cane, consisting of a central mass of pith with a hard external shell, but without the true bark which enables the trunks of other trees to increase gradually in thickness after beginning their growth as slender shoots. The young coconut palm is under the necessity of producing many leaves at the surface of the ground before the trunk can attain its full diameter and begin its upward columnar growth.

The two or three years that are lost before the upward growth of the trunk can begin are a very serious handicap in the race for existence among the luxuriant and tangled growth of shrubs, trees, and vines which promptly overrun any abandoned land in the humid Tropics. Exogenous plants begin the elongation of the stem immediately after germination, and usually produce much longer internodes in the shade than when exposed to the sunlight. Unless the human friends of the young coconut are at hand to keep down the other vegetation the period of infancy is not survived.

The rattans and other climbing palms that produce slender, long-jointed trunks are able to outgrow other vegetation, but all the palms that form thick, short-jointed trunks suffer the same disadvantage as the coconut. They are unable to compete with other quick-growing forms of vegetation that cover and smother young palms before they can escape by the building of trunks.

The coconut must be reckoned among the palms that are unable to develop without full exposure to sunlight. The seedling plants attain a considerable size in locations that are partially shaded, but this apparent growth arises from the nourishment stored in the huge seed. Large amounts of sunlight appear to be necessary to enable young coconut palms to make any independent growth. This intolerance of shade is a fact of primary importance in the study of the coconut, either from the botanical or from the agricultural standpoint. It explains why coconuts are not able to establish themselves as wild plants in any of the wide tropical regions of low elevation in which they are cultivated.

SOUTH AMERICAN ORIGIN OF THE COCONUT PALM.

As soon as we recognize that the coconut is unable to establish itself or even to maintain its existence on any tropical seacoast, we are no longer at liberty to believe that the species originated in maritime situations. It becomes evident that the home of the plant must be sought in interior localities where the young palms could escape competition with the more luxuriant types of tropical vegetation. While we imagine that the coconut can be disseminated by ocean currents to any part of the Tropics, it seems hopeless to fix upon any particular coast line as the original home of the species, but when we understand that the species must have originated in an interior locality the problem of origin is immediately simplified and very definite conclusions can be reached.

If the coconut could be submitted as a new natural object to a specialist familiar with all other known palms, he would without hesitation recognize it as a product of America, since all of the score of related genera, including about three hundred species, are American.^a With equal confidence the specialist would assign the coconut

^a The only member of the family Cocaceae that has an extra-American distribution is the African oil palm, *Elaeis guineensis*, a species rather closely related to the American *Elaeis melanococca*. Even in this case the idea of maritime distribution has become unnecessary. The African oil palm has been found in Brazil in an apparently wild state, and may have originated in that country. Dr. F. H. Knowlton, of the U. S. Geological Survey, has showed me seeds of the African oil palm which were taken from an albatross shot off the west coast of Africa by the United States Eclipse Expedition of 1889-90. The powers of flight of the albatross are such as to render it a much more effective agent of distribution than the ocean currents. Moreover, the oil palm does not behave as a littoral species, like the coconut.

to South America, because all other species of the genus *Cocos* are confined to that continent, and he would further locate it in the northwestern portion of South America, because the wild species of *Cocos* of that region are much more similar to the coconut than are those of the Amazon Valley and eastern Brazil. Thus, from a purely biological standpoint, it is reasonable to suppose that the vigorous and productive coconut palms reported by Humboldt in the interior districts of Venezuela and Colombia may have been growing near the ancestral home of the species.

In dealing with a plant like the coco palm we can be confident that it originated in a definite geographical region, along with the other similar and related species. To suppose that the same species has originated in two or more remote regions is quite as absurd an idea, from the standpoint of modern biology, as it would be in geometry to talk of a plane triangle including three right angles. It might be a matter of difficulty and debate to determine which of the other species of *Cocos* were most nearly related to the coconut, or which of the other American genera of *Cocaceae* were most nearly related to *Cocos*, but to insist that the coconut had sprung from the unrelated Malayan or Polynesian palms would be altogether fantastic. Biological facts, though seldom appearing to be as exact and invariable as those of mathematics, are for some purposes equally definite. Geometry gave us the sciences of geography and navigation, and also made it possible to understand the motions of the planets. Biology, like geometry, is a system of bearings and measurements which may assist us in the solutions of many problems.

The inability of the coconut to withstand the competition of ordinary tropical vegetation makes it unreasonable to suppose that the species originated in any region that had a natural forest covering. The fact that other related palms are much more tolerant of shade than the coconut makes it only the more probable that the coconut originally inhabited open places where it could have full exposure to the sun; that is, a place where the conditions were unfavorable for other types of vegetation, but favorable for the coconut. A condition that the coconut can tolerate and that excludes most other vegetation is the presence of salt in the soil. Many salt deposits are found along the eastern side of the Andes from Colombia to Peru. Cieza de Leon devotes a special chapter to the native salt industry of Colombia, mentioning many springs, streams, and lakes in the Cauca Valley, and especially in the district of Anzerma where the coconut palms were found.

Before I treat of the kingdom of Peru, or leave the government of Popayan, it seems to me well to give some account of the notable fountains there are in this land, and of the rivers of water from which they make salt, for thus the people are sustained, having no salt pits in these parts, and the sea being far distant. . . .

In the province called Cori, which is near the town of Anzerma, there is a river which flows with considerable force, and near it there are some ponds of salt water, whence the Indians obtain the quantity they require, and, making great fires, they place jars of this salt water on them, and set the water to boil until from an *arroba* there is not left half an *azumbre*. Then their experience enables them to convert the residue into as pure and excellent salt as is made from the salt-pits of Spain. Throughout the districts of Antioquia there are many of these fountains, and they make so much salt that they take it inland, and exchange it for gold, cotton cloth, and other things which they may require.

Beyond the great river which flows near the city of Cali, and near that of Popayan, towards the north, we discovered a village called Mungia. . . .

In this village of Mungia, and in another called Cenusara, we found some other fountains in mountains near a river, and from these fountains the natives made so much salt that their houses were full of it, molded into shapes exactly like loaves of sugar. They took this salt by the valley of Aburra to the provinces to the eastward, which have not been discovered or seen by the Spaniards to this day. This salt has made the Indians exceedingly rich. . . .

In the province of Anzerma, and in all its districts, there are fountains of the same sort, from which they make salt.

In the city of Cartago every citizen has his apparatus for making salt, which is prepared in an Indian village called Consota, a league from the city, where a small river flows. Near the river there is a mountain out of which comes a large spring of very black and thick water. The water is taken from this spring and boiled in cauldrons until it is nearly all evaporated, when a white-grained salt remains, as good as that of Spain. . . .

In the city of Popayan there are some of these fountains, especially among the Coconucos, but not so many, nor of such good quality as those of Anzerma and Cartago. At Pasto all the salt is obtained by trading, and it is better than that of Popayan. I have seen many springs, besides those which I have now described, with my own eyes, but it seems to me that I have said enough to make the reader understand the manner of procuring salt from these springs.^a

Herndon, who explored the upper waters of the Amazon in eastern Peru near the middle of the last century, mentions deposits of salt in numerous localities in the eastern valleys of the Andes.

. . . At a quarter past 10 we passed the Quebrada, or ravine of Huinagua, on the right. A small stream comes down this ravine, the water of which is salt. The people of Uchiza ascend it—a day's journey—to a salt hill, where they supply themselves with this indispensable article. At twenty minutes past 11 we passed another; and at 1 p. m. another, where the people of *Tocache* get their salt. It is a day's journey from Tocache to the mouth of the Quebrada, and another to the salt hills.^b

The hills of Pilluana, which we now soon passed, have their base immediately upon the river, on the right-hand side. They are about 300 feet in height, and stretch along the banks of the river for a quarter of a mile. The salt shows like frost upon the red earth at a distance; but seen nearer the heavy rains seem to have washed away the loose earth and left nearly the pure salt standing in innumerable cone-shaped pinnacles, so that the broken sides of the hills look like what drawings represent of the crater of a volcano, or the bottom of a geyser. Where the hills have been excavated, beautiful stalactites of perfectly pure salt hang from the roof in many varieties of shapes. There

^a Cieza de Leon, pp. 124-127. (See footnote, above, p. 287.)

^b Herndon, W. L., and Gibbon, L., *Exploration of the Valley of the Amazon*, pt. 1, p. 154. (32d Cong. 2d sess., Executive No. 36, 1854.)

are much higher hills back of these, that appear also to contain salt; so that there seems a supply here for all people and for all time.^a

We passed the salt hills of Callana Yacu, where the people of Chasuta and the Indians of Ucayali and Marañon get their salt. The hills are not so high as those of Pilluana, and the salt seems more mixed with red earth. It "crops out" on the banks of the river, which are shelving, and rise into gentle hills as they recede, covered with bushes and small trees.^b

Every year at this season the Indians of the Marañon and Ucayali make a voyage up the Huallaga for their supply of salt. They travel slowly, and support themselves by hunting, fishing, and robbing plantain patches on their way.^c

Unfortunately, this traveler saw no coconut palms, or at least made no note of them, but a reference to coconuts in eastern Peru has been pointed out to me by Professor Pittier in the surveys of the Intercontinental Railway Commission, near a place called Choros, on the Marañon River, at an elevation of 765 meters.

Vegetation existed only in narrow strips along the immediate edges of the side streams entering the Marañon, and consisted mostly of coarse bushes and undergrowth. At this particular point the natives had a small patch of sugar, and there were half a dozen cocoanut palms.^d

No coconut palms are reported by the English botanist Spruce, who explored the region of Tarapoto in eastern Peru and ascended the humid valleys of the Pastasa and Bombonasa rivers on his way to Quito.^e

It would be reasonable to turn to these saline districts of South America if any attempts were to be made to definitely ascertain the original home of the coconut by finding it in a truly wild state. Such a discovery is hardly to be expected, because of the probability that localities suited to the spontaneous growth of coconuts would have attracted human inhabitants, even in very early times. We may hope, however, to find a series of local varieties or subspecies of the coconut palm in these interior localities, varieties that will be more hardy and vigorous than the maritime forms of the palm cultivated in the humid parts of the Tropics, and more likely to thrive under semitropical conditions.

^a Op. cit., pp. 154, 155.

^b Op. cit., p. 165.

^c Op. cit., p. 168.

^d Intercontinental Railway Commission Report, vol. 3, p. 16. On a previous page of the same series (vol. 2, p. 61) coconut palms are noted as cultivated "in a few places" in the Cauca Valley of Colombia.

^e Spruce, Richard, Notes of a Botanist on the Amazon and Andes, edited by A. R. Wallace, vol. 2, ch. 17. (London, 1908.) Also Kew Bulletin of Miscellaneous Information, 1909, p. 216.

DOMESTICATION OF PALMS IN ANCIENT AMERICA.

The general acceptance of the idea that agriculture and other arts of civilization originated in the Old World has undoubtedly tended to complicate the question of the origin of the coconut palm, as studied by Seemann, De Candolle, and other writers on the subject. As the art of agriculture must have begun with the domestication of wild plants, it may be argued that the plants must have existed in the regions where domestication was practiced. The fact that the date, the betel nut (*Areca*), the Palmyra palm (*Borassus*), the toddy palm (*Caryota*), and the sugar palm (*Arenga*) were domesticated in the East Indies would naturally incline the ethnologist to include the coconut in the same list, especially if there appeared to be a difference of botanical opinion on the question of origin. It is important, therefore, from the ethnological standpoint, to take into account the fact that several other palms were more or less completely domesticated in ancient America, some of them relatives of the coconut. The importance of the Old World series of domesticated palms appears greater because higher stages of civilization were reached in the Old World, but the relative importance of palms in the indigenous agriculture of America appears to be fully as great as in the Old World Tropics.

DOMESTICATION OF THE PEACH PALM IN SOUTH AMERICA.

The Indians of the northwestern part of South America—the same region that must be looked upon as the original home of the coconut—domesticated the so-called “peach palm” (*Guilielma*), one of the numerous relatives of the coconut palm. (Pls. 55 and 56.) The peach palm is armed all over with long, slender, shining black spines, sharp as needles, but in spite of this unfriendly exterior the Indians have found it worthy of cultivation. Its handsome red or yellow fruits serve as an important article of diet among the natives of a vast region along the eastern slopes of the Andes, from Brazil and Peru through Ecuador, Venezuela, and Colombia, and even beyond the Isthmus of Panama in the Central American Republic of Costa Rica.

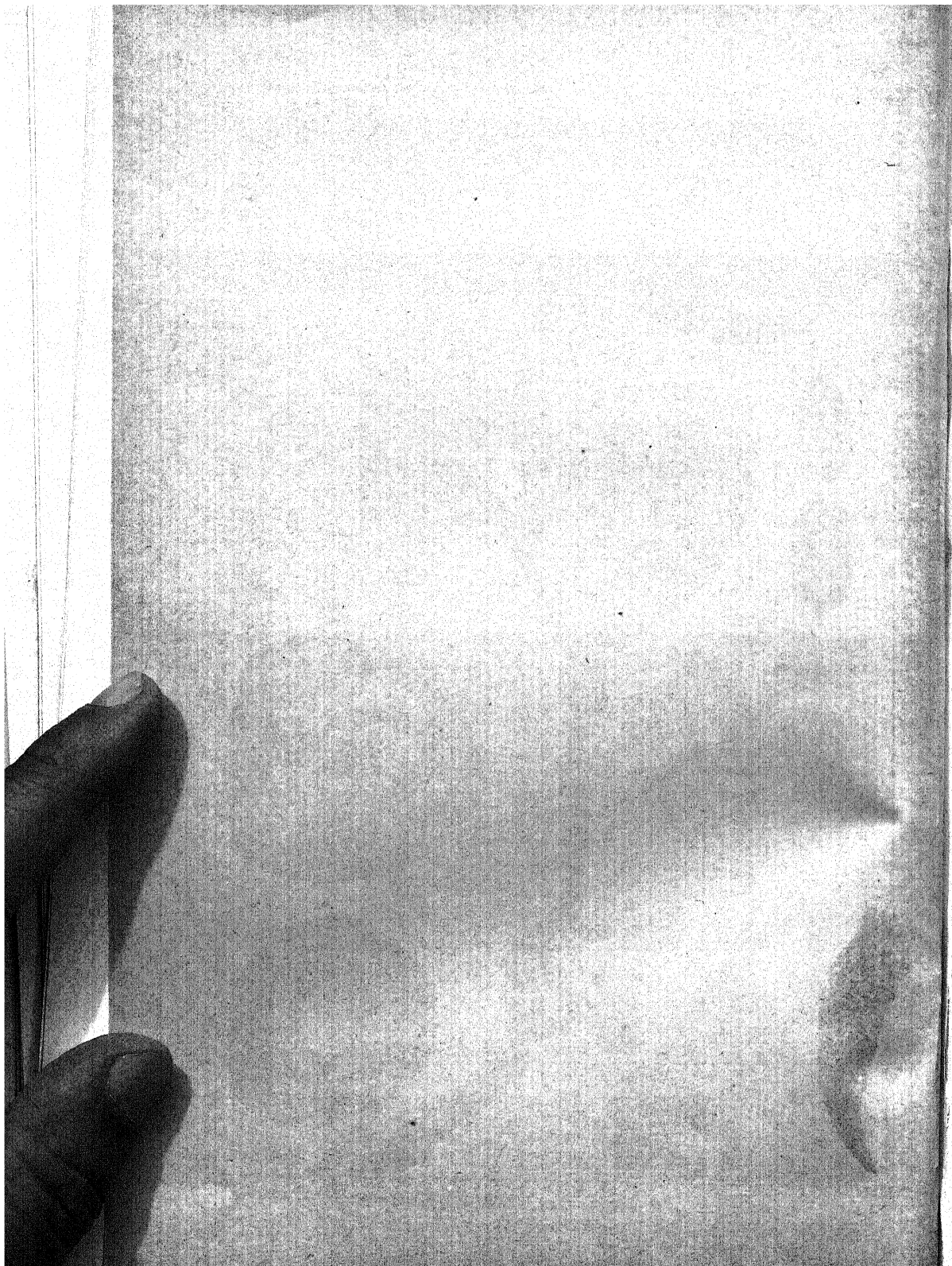
The peach palm appears to be as thoroughly domesticated among the Indians of South America as the date palm among the Arabs. Several botanical explorers of South America have described this palm and its importance among the Indians. The following extract from Alfred Russel Wallace’s “Palm Trees of the Amazon” shows its status in the interior districts of Brazil:

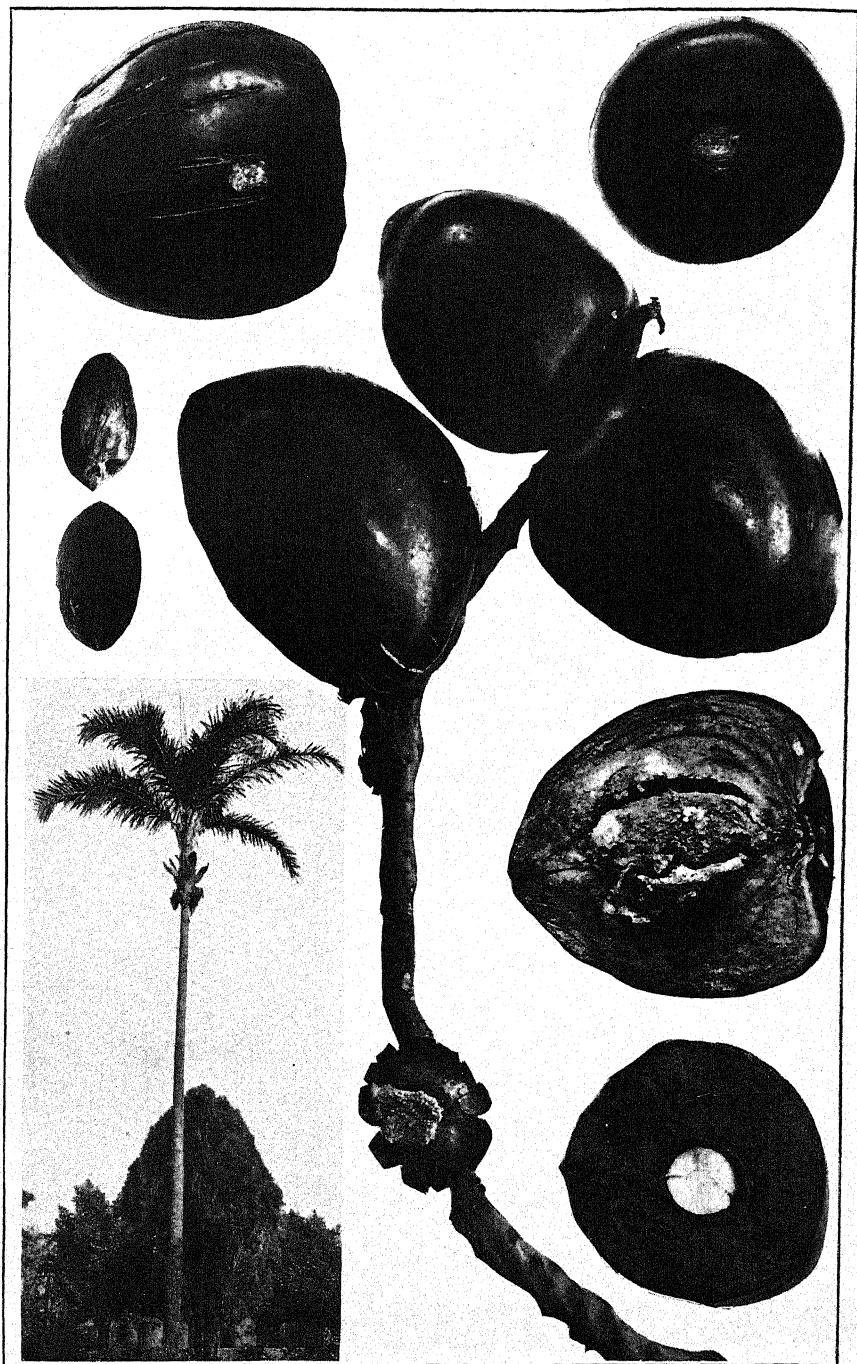
The fruit is about the size of an apricot, of a triangular oval shape, and fine reddish-yellow colour. In most instances the seed is abortive, the whole fruit being a farinaceous mass. Occasionally, however, fruits are found containing the perfect stony seed, and they are then nearly double the usual size. This production of undeveloped



PEACH PALMS (*GUILIELMA SPECIOSA*) IN COSTA RICA.

A relative of the coconut, domesticated in South America. Photograph taken at the coffee estate of Señor Federico Tinoco, Juan Viñas.





PEACH PALM (*GUILIELMA SPECIOSA*) WITH FRUIT AND SEED.

Specimens from the cacao estate of Mr. Leon G. Laprade, Rio Hondo, Costa Rica. The small photograph of an adult tree with fruit clusters was made at San Juan, Costa Rica. (Details natural size.)

fruits may be partly due to change of soil and climate, for the tree is not found wild in the Amazon district, but is invariably planted near the Indians' houses. In their villages many hundreds of these trees may often be seen, adding to the beauty of the landscape, and supplying the inhabitants with an abundance of wholesome food. In fact it here takes the place of the cocoa-nut in the East, and is almost as much esteemed.^a

The peach palm is one of the gregarious or cespitose species that send up shoots from underground rootstocks. It is regularly propagated by the use of these young shoots as cuttings, much as in the case of the date palm. It might be inferred that the culture of the peach palm is older than that of the date because some of the varieties are seedless. The propagation of plants from cuttings appears to represent an older system of agriculture than the raising of plants from seeds. Some of the more primitive Indian tribes are accustomed to grow cassava, sweet potatoes, and other root crops from cuttings, though they do not plant corn or beans. The celebrated English botanist, Richard Spruce, who spent eleven years in the interior of South America, was especially impressed with the agricultural importance of the peach palm among the Indians, and attempted to solve the problem of its origin by finding it in a wild state.

. . . I tried in vain to find a root for this name [pijiguo] in any of the native languages; and when I asked the people where they supposed the palm had originally come from they pointed westward and said, "From the Cordilleras;" and I got a similar answer from the natives of the Uaupés.

When at length I reached those Cordilleras and traveled along their eastern foot from 7° S. latitude to the Equator, I found, indeed, the Peach Palm very abundant, but still only in the neighborhood of habitations, and always a cultivated plant. If, however, I remained in as complete ignorance as before of its true native country, I saw at once that the Venezuelans, along with the plant, had got also its name from the Andes, but travestied; for the Peruvians call it (in their native Quichua) "Pisho-guayo," i. e. Bird-Fruit, whence to "pijiguo" the transition is easy. . . .

Although I am compelled to leave the native country of the Peach Palm doubtful, I quite expect the wild plant will still be met with in some unexplored recess of the Oriental Andes, perhaps with the fruit so much smaller and drier than what it has become by long cultivation as to be not easily recognizable. Spruce, Richard, *Palmae Amazonicae*, Journ. Linn. Soc., vol. 11, pp. 81, 82, 1871.

A FIBER PALM DOMESTICATED IN BRAZIL.

Wallace also reports the domestication of another of the spiny relatives of the coconut in the interior of Brazil, not for the sake of the fruits, but for a fiber derived from the young leaves:

Every part of this palm [*Astrocaryum vulgare*] bristles with sharp spines so as to render it difficult to handle any portion of it; yet it is of great importance to the Indians, and in places where it is not indigenous, is cultivated with care in their mandioca fields and about their houses, along with the "Pupúnha" and other fruit trees. Yet they use neither the fruit, the stem, nor the full-grown leaves. It is only the unopened

^a Wallace, A. R., *Palm Trees of the Amazon and their Uses*, pp. 93-94. (London, 1853.)

leaves which they make use of to manufacture cordage, superior in fineness, strength and durability to that procured from the *Mauritia flexuosa*. They strip off the epidermis and prepare it in the same manner as described in the account of that species, but while the "miriti" is principally used for hammocks, the "tucúm" serves for bow strings, fishing-nets and other purposes where fineness, combined with strength, is required. . . .

The Brazilians of the Rio Negro and Upper Amazon make very beautiful hammocks of fine "tucúm" thread, knitted by hand into a compact web of so fine a texture as to occupy two persons three or four months in their completion. They then sell at about 3£ each, and when ornamented with the feather-work borders, at double that sum. Most of them are sent as presents to Rio de Janeiro.^a

The method of stripping the epidermis and of twisting it into cords on the naked thigh, as described by Wallace, appears to be exactly the same as that used among the native negroes of West Africa in preparing the fiber known commercially as "raffia," which is derived from the epidermis of the young leaves of the African wine palm (*Raphia*).

DOMESTICATION OF THE PACAYA PALM IN GUATEMALA.

Another domesticated palm, not hitherto recognized as such, exists in the Coban district of eastern Guatemala. It is a species of *Chamaedorea*, locally known as *pacaya*. It is not grown for the sake of its fruits or leaves, but for the fleshy inflorescences that are cooked and eaten as a salad. Only the male plants furnish the edible inflorescences, this palm being dioecious, like all of the species of *Chamaedorea*. The whole of the spadix or flower-bearing part of the inflorescence is eaten and is of very delicate texture. It compares with other so-called "palm cabbages" much as cauliflower does with other garden cabbages, the cauliflower representing the young tender inflorescence of the plant instead of the fleshy leaf bud. The taste of the cooked *pacaya* is slightly bitter, but the flavor is generally relished, not only by the native population, but also by resident Europeans.

The difficulty of obtaining cabbages from other palms is that the whole palm has to be sacrificed in order to obtain the small mass of tender edible tissue in the terminal bud. With the *pacaya* no such sacrifice is necessary. The removal of the inflorescence does not injure the palms, and they continue to produce a succession of crops during a considerable period of years. The *pacaya* is not planted as a field crop, but is grown in considerable numbers as a garden plant, not only about Coban, but in Purulhá and other towns of eastern Guatemala. In the wild state it seems to be confined to heavily shaded, humid valleys with other related species, but it also thrives when planted in the open. The palm grows to a height of 15 or 20 feet, and has a crown of very handsome, gracefully drooping leaves.

^a Wallace, op. cit., pp. 105, 106.

The smooth green trunk has a diameter of 2 or 3 inches. The unopened inflorescences are about the size of a large ear of corn and are inclosed in green spathes somewhat similar to corn husks.

DOMESTICATION OF PALMETTOS IN MEXICO.

One of the native arts that flourishes in many localities in tropical America is the weaving of hats from the fibrous leaves of various species of fan-leaved palms related to the Florida palmetto. These are not the same as the so-called Panama hats made in South America from the leaves of *Carludovica*, which is not a true palm. Large numbers of the palmetto hats for local use are made in Guatemala and Mexico, though the most advanced state of the palmetto hat industry is found in Porto Rico, whence large quantities have been exported to the United States during the last decade.

The Porto Rican hat palmetto, *Inodes causiarum*, does not appear to be regularly cultivated, though it is valued and allowed to grow in many places for the sake of the leaves. The largest quantity of these palms is found along the seabeach at a place called Joyua, on the west end of the island between Mayaguez and Cabo Rojo.

Palmettos grow wild in great abundance along the Pacific coast of Guatemala and the adjacent district of Soconusco in the Mexican State of Chiapas, and their leaves are gathered in large quantities for the thatching of houses and the weaving of hats. The hats themselves and the straw, or "paja," prepared for weaving are important articles of domestic commerce, carried about on the backs of the Indians and sold in all the native markets. To secure additional supplies of the material the palms are also commonly planted about the native towns, sometimes in considerable numbers. Even on the east side of Guatemala in districts where there do not appear to be any native palmettoes, the Indians have planted many of them in their villages, as at Cajabon and San Augustin, near El Rancho, and at other places. In southern Mexico the planting of palmettos is carried still further, thousands of these palms being found in the larger towns of the Soconusco district. Regular field plantings of palmettos were seen about Comitán in southwestern Chiapas and again near Merida in Yucatan. Palmettos are also grown extensively at San Bartolomé, Chiapas, as reported by Mr. G. N. Collins, though no field plantings were noticed.

PARTIALLY DOMESTICATED PALMS.

In addition to the palms that may be said to have been definitely domesticated in the American tropics, there are several others that may be described as partially domesticated. Though seldom actually planted or cared for, they are on a distinctly friendly footing with

mankind, and are much more abundant in inhabited regions than in the undisturbed forest.

These partially domesticated palms take advantage of the clearings made for the planting of corn, cassava, and other crops, and repay this indirect assistance by their fruits or other parts sufficiently useful to cause them to be tolerated, if not actually prized. Some of these voluntary camp followers of primitive agriculture are of distinct importance, so much so that they would undoubtedly be cultivated if they did not grow spontaneously without the need of direct assistance. Some of them are worthy of much wider consideration in tropical agriculture than they now receive.

The royal palm of Porto Rico (*Roystonea borinquena*) is a tree of much importance to the natives of the island, a large proportion of their houses being roofed with the tough sheaths of the leaves of this palm, known in the island as "yagua." While the leaves are alive the sheaths form complete cylinders 4 or 5 feet long, but when the leaves fall the sheaths split down one side and are then cut off and flattened out to form large leathery shingles. The side walls are often made of the same material or from the hard surface layer of the trunk of the same palm, split up into board-like strips.

The fruits of the royal palm are small and are not eaten by man, but they have an oily flesh much relished by the pigs, so that the palms are generally welcomed in the pastures, where they are vastly more abundant than on lands where the forest is allowed to grow. It is claimed that the fruits dropped by each adult palm will keep a pig in good condition without any other food than grass. There can be no doubt that the royal palm is a more important species in Porto Rico than the coconut itself and that it is worthy of much wider consideration in tropical agriculture.

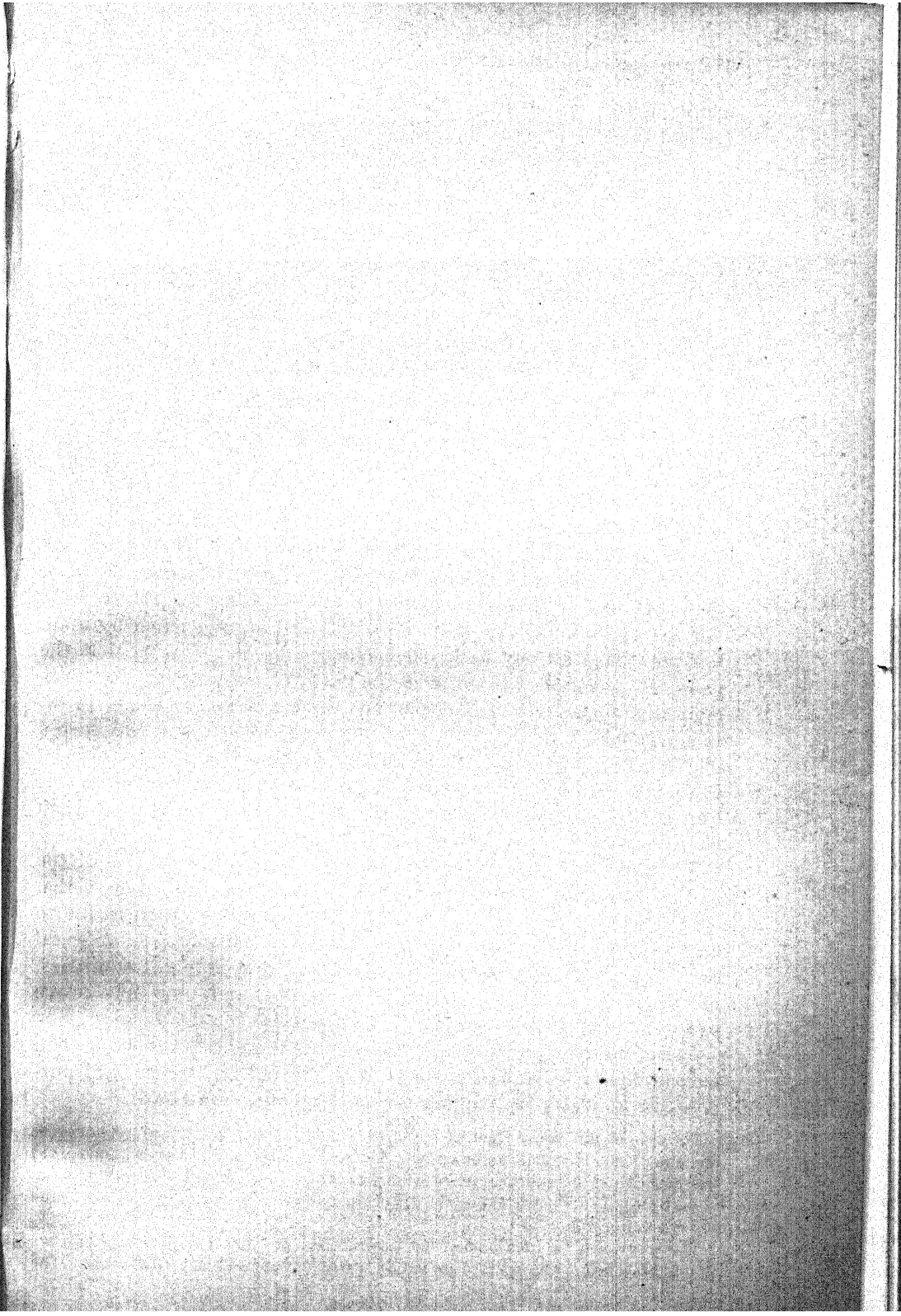
The American wine palm, *Acrocomia*, is found in all parts of the American tropics, from Paraguay on the south to Porto Rico, Cuba, and Mexico on the north. Whether this wide distribution is due to natural agencies or to human assistance is not known. Several species of *Acrocomia* have been described from different countries, but their characters are not very distinctive, and they may prove to be only local variations of a single species.

In most places the *Acrocomia* palms are found only about human habitations or in lands that have been cleared for agricultural purposes, as indicated by Wallace for the Pará region of Brazil.

The stem of this tree is about 40 feet high, strong, smooth and ringed. The leaves are rather large, terminal and drooping. The leaflets are long and narrow, and spread irregularly from the midrib, every part of which is very spiny. The sheathing bases of the leaf-stalks are persistent on the upper part of the stem, and in young trees clothe it down to the ground.

The spadices grow from among the leaves, erect or somewhat drooping, and are simply branched. The spathes are woody, persistent and clothed with spines. The

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THE COYOL PALM (*ACROCOMIA VINIFERA*), COSTA RICA.

A relative of the coconut, partially domesticated in Central America. The photograph was made at La Colombiana banana estate, near Port Limon. This species was originally described by Oersted from Costa Rica.

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fruit is the size of an apricot, globular, and of a greenish-olive colour, and has a thin layer of firm edible pulp of an orange colour covering the seed.

This species is common in the neighbourhood of Pará, where its nearly globular crown of drooping feathery leaves is very ornamental. The fruit, though oily and bitter, is very much esteemed and is eagerly sought after. It grows on dry soil about Pará and the Lower Amazon, but it is quite unknown in the interior.^a

The native Porto Rican species, *Acrocomia media*, grows spontaneously in the sparse forests that occupy lands too barren and craggy for agricultural use, and the same is true of the Central American species, *Acrocomia vinifera*, in Guatemala and Costa Rica (pl. 57). It is possible, however, that these individuals that appear to be growing wild have only escaped from cultivation through the accidental scattering of the seeds.

The wine palms are well equipped to establish themselves in the vicinity of human habitations. The trunks and leaves are beset with sharp, black, needle-like spines, which protect them against grazing animals, and the crown of leaves formed by the palms while still quite young is thick enough to occupy the land and even to withstand fire when clearings are made around it. Even after the palm has grown tall enough to expose the trunk the wood is so hard that the Indians avoid cutting it unless the palms become so abundant as to interfere with the lands they need for their corn or other crops.

The accounts of the early explorers indicate that the sap of the wine palm was in general use as a beverage among the Indians, but its popularity seems to have greatly declined now that the white man's liquors are obtainable. The palm is cut down to obtain the sap, which continues to flow out of the upper end of the severed trunk for several days.

The wine palms bear spherical fruits which attain a diameter of about 1½ inches. There is an outer layer of oily pulp with a slightly acid flavor, combined with a dense coating of fine fibers, that adhere to the wall of the nut inside. The pulp is often eaten by children or by adult Indians on the road, though hardly to be reckoned as a staple article of diet. The nut itself, without the fibers, is about the size of a horse-chestnut, with a hard shell like that of a coconut and of about the same thickness. The inclosed kernel is solid and has a taste like coconut meat. In times of famine these nuts are extensively eaten, but usually they go to waste. It is often proposed to utilize them for the extraction of their oil, which is said to be much like that of the coconut, but the problem of collecting and cracking the nuts has not been solved, unless it be in the Paraguay region of South America. It is said that the nuts are cleaned of the fiber by being eaten by cattle and that the kernels are becoming an article of export to Europe.

^a Wallace, A. R., *Palm Trees of the Amazon and their Uses*, p. 97.

Other partially domesticated palms are found among the species of *Attalea*, known in some countries as *corozo*, in others as *manaca*. The *Attalea* palms are among the most magnificent members of the group and would undoubtedly be in demand for ornamental planting if they once became known. They bear a crown of immense leaves, often attaining lengths of from 30 to 40 feet, and these do not droop as in other long-leaved palms, but spread very gracefully by the bending of the long midribs. The leaves are extensively used in some localities for thatching the houses of the natives and for making the natives substitutes for umbrellas and raincoats.

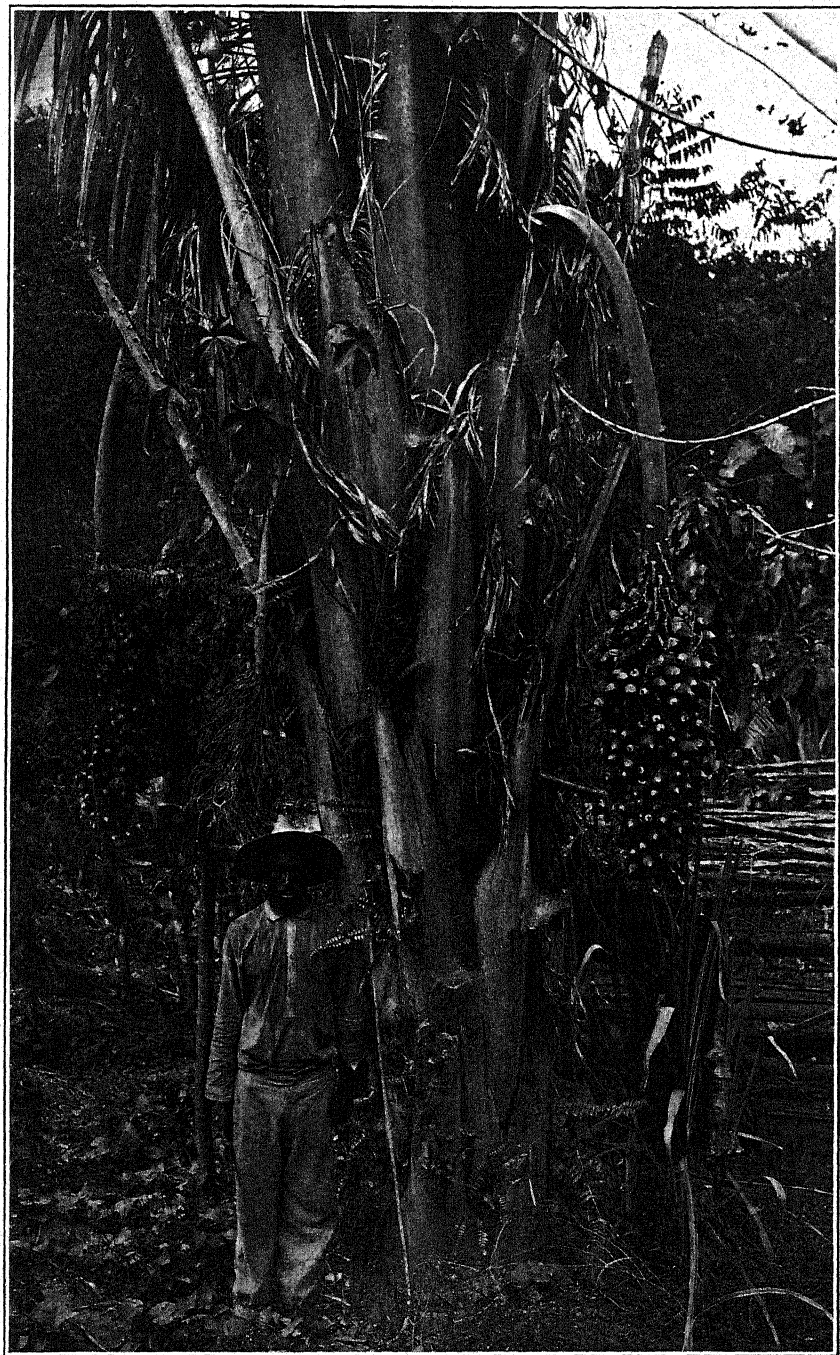
The fruits of the *Attalea* are born in enormous clusters, weighing 200 pounds and upward (pl. 58). In some species there is a pulpy outer husk with much the same texture and taste as in *Acrocomia*. In other species, such as *Attalea cohune* of eastern Guatemala and British Honduras, the nut has a thin dry husk and a very thick bony shell. The kernels are very hard, but can be eaten in times of scarcity, or made to yield oil by the application of heat. Considerable quantities of the kernels are gathered in Mexico and the oil extracted for the making of soap and for other domestic purposes. Vast quantities of these nuts might be gathered in other parts of the American tropics if any profitable use were found for them.

As the *Attalea* palms have no spines to protect them from the grazing animals or from man, they are at a disadvantage in comparison with *Acrocomia* and have not attained so wide a distribution. On the other hand, they are much better able to compete with other forest growth, so that they are often found in vast numbers in regions that have been abandoned by the Indians in the last century or two, and now distinguish such reforested areas from the forests of older growth where the long-lived hard-wood trees have taken full possession to the exclusion of the *Attalea* palms.^a

ORIGIN OF THE NAMES COCO AND COCOS.

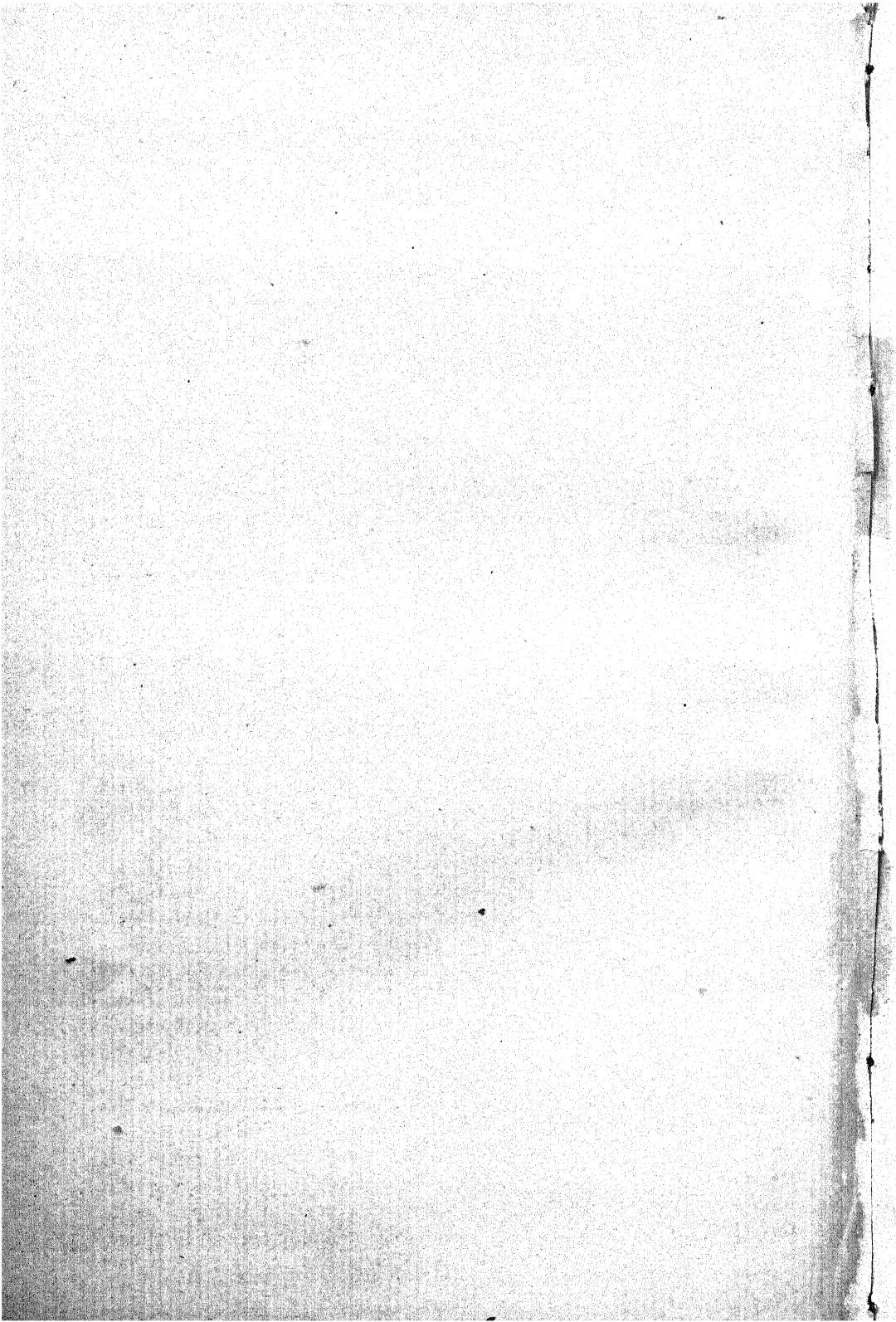
The lack of native American names for the coconut has been accepted as proof that the palm could not have existed in America before the arrival of the Spaniards. This argument is considerably weakened by the probability already noted that the name "coco" itself is of American origin. It is certain, at least, that the Spaniards did not need to bring the word "coco" to America, since it was a favorite plant name in several Central American languages. It is applied in particular to plants that have bulbs or bulbous roots. For example, the bulbous rootstocks of *Xanthosoma*, a taro-like plant

^a Vegetation Affected by Agriculture in Central America, U. S. Department of Agriculture, Bureau of Plant Industry, Bull. No. 145.



TRUNK AND FRUIT CLUSTERS OF THE COROZO OR MANACA PALM (*ATTALEA COHUNE*),
EASTERN GUATEMALA.

A relative of the coconut, partially domesticated in Central America. The photograph was made near Panzos, Alta Verapaz.



extensively cultivated in Porto Rico under the native name *yautia*, are still commonly called *cocos* in Jamaica.

Peter Martyr used the word *coccos* in his ninth Decade in describing coconuts in the East Indies (*Coccos appellat fructus illos . . .*), but no modern writer seems to have recorded the word as a native East Indian name of the coconut. None of the numerous names given in Watt's Dictionary of the Economic Products of India and in Wallace's vocabularies of thirty-three languages of the Malay Archipelago has any apparent resemblance to *coco*, unless it be *copra*, the East Indian name of the dried meat.

Some authorities note an ancient Egyptian word as the original of the Greek *kouki* of Theophrastus and the Latin *cuci* of Pliny. Seemann denies that the Egyptian *kouki* referred to the coconut, but applies it to a native African fan palm, *Borassus*. It is also possible to identify the *cuciophoron* of Theophrastus with the doum palm of Upper Egypt (*Hyphaene*).^a Indeed, the word "*kouk*" is still to be heard in the bazaars of Cairo as the name of the horny endosperm of the doum palm, commonly used for making the beads of rosaries, and other small objects.

Some etymologists would assimilate *kouki* with *kokkos*, a general Greek word for fruit, berry, or seed, the same as the Latin *coccus*. The word *coccus* seems to have come into Latin as the name of the Kermes insect (*Coccus ilicis*) that yielded the scarlet dye, rather than as the name of a seed or a berry. Nevertheless, we find among later post-Columbian writers of botanical Latin, such as Piso, the expression *Coccus Indica* taking the place of *Nux Indica* as the name of the true coconut and *Coccus Medica* or *Coccus Maldivica*, instead of *Nux Medica* or *Nux Maldivensium*. Eden's English translation of Oviedo shows the word *cocus*; Oviedo himself adhered consistently to *coco*, except as he wrote *cocos* in the plural number, as in the heading of his chapter. Linnæus, in his older works, such as the *Hortus Cliffortianus* and the *Flora Zeylanica*, also used the generic name *Coccus*. The change to *Cocos* seems to have been made in the first edition of the *Species Plantarum* (1753) without any previous author being indicated as having used the name in this form. The fourth edition of *Genera Plantarum* (1752) uses the old spelling *Coccus*, but the fifth edition (1754) adopts the new form *Cocos*.

The Latin and Greek derivations that have been invented for the word may have quite as little basis in fact as the fanciful theory given by Oviedo, and repeated by many later writers, that the name was suggested by the resemblance of the base of the shell to the face of a monkey. The Spanish language has a verb *cocar*, meaning to make faces like a monkey, and even a noun *coco*, meaning ogre or bugbear,

^a Greene, Edw. L., Landmarks of botanical history, pt. 1, Smiths. Misc. Coll., vol. 54, p. 132. (1909.)

connected by philologists with the Greek adjective *kakos*, the equivalent of the English word bad. Eden's translation^a elaborates Oviedo's original statement to the extent of definitely ascribing this etymology to the Indians, and associating it with the cry of the howling monkey.

OTHER AMERICAN NAMES OF THE COCONUT.

It now appears that names other than coco are applied to the coconut by aboriginal Indians. Such names have been found by Prof. H. Pittier among the inhabitants of the southern part of the Central American republic of Costa Rica, where several very primitive tribes have hidden themselves in the forest and avoided contact with the Spanish colonists. The name *ko-ko* is used by the Cabécara, Dorasque, and Guaymí tribes; the Cunas say *o-kób*, also slightly suggestive of copra, while the Bribri and Brunka people have quite distinct terms, *sura uó* and *sia uá*, respectively.

According to Professor Pittier the Brunkas are good sailors, who make voyages of considerable length along the Pacific coast, though they are careful to keep their canoes within sight of land. The Brunkas live not far from the Burica peninsula where Oviedo found the coco palm in special abundance in the early part of the sixteenth century. The Burica district is also the nearest part of the mainland to Cocos Island. That this region possessed at one time a much more advanced civilization is shown by the graves of the adjacent Chiriqui district of Panama, and other ancient remains discovered in the southern part of Costa Rica by Professor Pittier.

It is to be expected that other native names will be found in the interior districts of South America where the coconut is known to exist, but these regions are still largely unexplored. The native names of the coconut in Brazil, *inaíaguacu*, recorded by Piso and Marcgrave in Brazil, have been noted in a previous chapter. According to Martius the name *inaja* or *inaia* is also applied in Brazil to another related palm, Maximiliana. Martius associates the Tupi names for fruits, *yba*, *iba*, and *ia* with such words as *nha* or *nia*, which relate more specifically to the large fruits of the Brazil-nut tree, *Bertholletia excelsa*, and then points out the similarity to *niu*, the Hawaiian name of the coconut.^b

^a See footnote a, p. 278.

^b Martius, C. F. P., Beiträge zur Ethnographie und Sprachenkunde Amerika's, vol. 2, p. 417. (Leipzig, 1867.) In Marcgrave's vocabulary of a native Brazilian language, published in 1658, the word *nha* is said to signify heart (*cor*).

DISSEMINATION OF THE COCONUT PALM BY PRIMITIVE MAN.

Without the recognition of human agency in its dissemination the history of the coconut would be likely to remain forever as mysterious as it was to the eminent botanist Seemann, who traversed the subject in several of his books in attempting to solve the problem by means of natural agencies alone:

... And the great puzzle has been, whence did it originally spring? Though having paid considerable attention to this subject, I am not acquainted with any theory, nor have been able to start one myself, which would be in unison with the part the Coconut plays in different countries. ^a

Seemann was inclined to believe that the coconut palm must have been a native of Polynesia because of its extreme economic importance in that part of the world. In support of this view, and in opposition to the idea of Asiatic or Malayan origin which previous writers had advanced, Seemann argued that the coconut could not have been brought to the Pacific islands from the west, because colonists from Asia would certainly have brought the Asiatic art of bleeding the sap from the palms by cutting the young flower stalks, to make toddy and sugar from the juice. Such facts tend to show that the original inhabitants of the Pacific islands did not derive their agricultural habits from Asiatic sources, and that the more modern contacts with Asia have also been very slight, since they have left the Polynesians in ignorance of the art of making toddy.

... Had the Polynesians therefore once known the process, they would probably never have forgotten so easy a way of obtaining sugar, vinegar, yeast, and a pleasant drink, the strength of which may be regulated by time to any man's taste. So either the Polynesians could never have come from eastern Asia, or else, after spreading over the South Sea, ages must have elapsed before the cocoa-nut made its appearance in these waters, so that the process of toddy-making (there being no other suitable Polynesian Palms to operate upon) had been entirely forgotten, and even disappeared from native traditions. Under such circumstances, it behooves us to suspend our final judgment whether Polynesia be or be not the native country of the cocoa-nut. ^b

If we admit Seemann's argument, and there is no good reason for rejecting it, we can not suppose that the original settlers of the Pacific islands came from the Malay region, for the coconut is the one thing that they would have taken with them, if all else had been left behind. It not only furnishes in that part of the world the chief ration for native voyages, but is the only source of fresh water on many of the smaller islands, and is thus indispensable for human existence.

The fiber of the husk of the coconut is equally necessary to the Polynesians in the building and handling of boats. The mystery

^a Seemann, B., Dottings on the Roadside, in Panama, Nicaragua, and Mosquito, p. 152. (London, 1869.)

^b Seemann, op. cit., p. 154; Flora Vitiensis, p. 276. (London, 1868.)

clears only when we are prepared to admit that the original colonists in the Pacific islands were native of the same continent as the coconut palm, so that they could take with them the cultivated plants on which their future existence depended. By keeping close to the practical agricultural facts we avoid the confusion to which De Candolle and Seemann were brought by conflicting theoretical methods of ascertaining the origins of plants. The uses of the coconut have been most highly developed in the Pacific islands because lack of other plants has compelled the inhabitants to depend more and more upon the coconut. Necessity has given rise to the multiplicity of uses, but the palm itself had to be brought from the only part of the world where such palms grew—South America.

The relatively slight economic importance of the coconut in America could be given as a reason for believing that the palm was not introduced into America by the Polynesians in the same way that Seemann used the absence of toddy in Polynesia to prove that the palm was not brought to the Pacific islands by people from Asia.

It is gratuitous to object to human agency as accounting for the spread of the coconut since there were other cultivated tropical plants, such as the sweet potato and the banana which were also cultivated on both sides of the Pacific, and must have been carried across by the men who knew and used them. They are propagated only from cuttings, would not survive soaking in salt water, and do not grow on sea beaches. The indications are that nearly all the cultivated plants which Polynesia shared with America were natives of America, but whatever their source, they do not permit us to doubt that there was communication across the Pacific by primitive agricultural people. Ethnological evidence for such communication may also be found in the similarities now commonly recognized between the natives of America and the present inhabitants of eastern Asia and the Malay region. That the straight-haired peoples of the East Indies are not true aborigines of the countries they now occupy is shown by the presence among them of remnants of the former curl-haired populations, such as the Ainus in Japan, the Negritos in the Philippines, the Alfuros of Gilolo and Ceram, the Papuans, and the Andamanese. On the continent of Asia as well recent investigations are showing that primitive peoples related to the Negritos or to the Ainus preceded the Malayan and Mongolian occupations.

That the present Polynesians do not more closely resemble the natives of America does not warrant an objection to the idea that the coconut palm was originally carried into the Pacific islands from America. Ethnologists are familiar with the fact that the prevailing direction of recent racial movements in the Pacific has been from west to east. Whatever may have been the conditions in the remote times when the islands were first occupied, the island people have

had more recent contacts with the Malayan and Melanesian races. This eastward movement into the Pacific explains the presence, even in the most eastern archipelagoes, of many seedless varieties of the breadfruit, banana, and other Malayan plants, and of an infusion of Papuan or Melanesian blood. Yet these later influences have not destroyed the essential likeness of the Polynesian and Malayan culture to that of ancient America. The general unity of the Malayo-Polynesian language and the similarity of the people and their customs to those of the American Indians are more obvious in the remote islands, such as New Zealand, Easter Island, and Hawaii, than in the equatorial archipelagoes, where the Melanesian influences are more apparent. The Polynesians have traditions and genealogies that refer to the introduction of the breadfruit as having taken place about eighty generations or two thousand years ago, but this eastward migration that carried the breadfruit need not have had any connection with the westward migration which carried the coconut into the Pacific from America, and which probably took place at a much more ancient period.

Nor is it necessary to believe that contacts of the islanders with America entirely ceased during the modern period of eastward migration. The presence of the banana in pre-Spanish America forbids such an assumption. In addition to numerous traditions of the arrival of people from the seas, in Peru and elsewhere, there was the definitely reported historical incident of the black, frizzle-haired people of the Isthmus of Panama, which can hardly be explained except by supposing that a tribe of Polynesians had established themselves on the Isthmus when Balboa crossed it and discovered the Pacific Ocean.

The origin of the coconut in America and its dissemination by human agency to the tropics of the Old World do not stand alone as botanical theories, but are in full accord with more recent and well-established discoveries in the fields of ethnology and archaeology. It is now generally admitted by ethnologists that the ancient civilizations of tropical America were of native, indigenous origin and not imported from abroad. In Egypt and Assyria, on the contrary, it does not appear that the earliest civilizations were indigenous. Recent discoveries make it possible to trace them back to the shores of the Persian Gulf and to southern Arabia, and to a seafaring exotic race, skilled in agriculture and navigation.

That the primitive agricultural people who distributed the coconut and other American plants over the islands and shores of the Pacific and Indian oceans came originally from America is a possibility that appears worthy of careful consideration by students of botany and ethnology. The tropical contact of the two hemispheres was so remote in time, and the subsequent changes have been so great on

both sides of the Pacific, that the ethnological evidence alone might not be sufficient, but the addition of definite botanical data may yield conclusive proof. The earlier idea of an Asiatic origin of American civilizations having been given up, the tendency has been to believe that agriculture and other arts of civilization have developed quite independently on the two sides of the Pacific. But even if we were willing to believe in closely parallel developments in customs and arts, this could not explain the prehistoric distribution of the same cultivated plants over the Tropics of both hemispheres.

ORIGIN OF CULTIVATED VARIETIES OF THE COCONUT PALM.

One of the most convincing arguments for the Malayan origin of the coco palm was the existence of many and very diverse varieties in the East Indies. It was a favorite line of reasoning with De Candolle that the native home of a species was the region in which it had been longest in domestication. The length of the period of domestication was inferred from the number of varieties as a measure of the time that selection had been at work. Such calculations were applied to the sugar cane, the taro, and numerous other plants.

In dealing with the coco palm this plan seemed to be particularly effective, for nearly all of the recorded varieties are in the East Indies. The coco palm in America is not as uniform as commonly supposed, though the varietal diversities do not approach those of the Malay region.

Careful consideration of the evolutionary argument will lead, however, to a conclusion directly opposite to that reached by De Candolle, for the greatest and most definite variations of a cultivated plant are much more likely to occur and be preserved outside its natural range, where intermixture with the wild type of the species is prevented. There are many reasons for believing that the abrupt and striking "sports" that appear among our cultivated plants are not, in reality, caused by selection, but are induced by new conditions and by the state of inbreeding that generally accompanies domestication.

The normal or wild type of a species is generally prepotent over the varieties which have arisen in domestication, so that the "improved" breed rapidly "deteriorates" when allowed to become crossed with the wild stock. Darwin and many later experimenters have proved, also, that when diverse breeds are crossed the offspring are very often not intermediate between the breeds, but tend to revert to the ancestral form. The breeders of high-grade varieties look upon such mongrels as degenerate, but from the standpoint of the evolutionist they may be said to be recovering from the injurious results of inbreeding. It was noticed, for example, that in parts of Guatemala, where the wild tropical papaw (*Carica*) is common, the cultivated trees also have very small fruit. The tendency to such

reversion would be particularly strong in plants like the palms, cross-fertilized by the wind.

If economic importance and multiplicity of variations were to decide the question of origin, coffee could be proved to be a native of the East Indies or of Central America, instead of Abyssinia. Many striking variations of the coffee plant have arisen in the American Tropics, and none, as far as known, in Abyssinia. The breadfruit could be shown by such reasoning to be a native of the eastern archipelagoes of Polynesia, where most of the specialized varieties are found and where the tree has an economic importance and an agricultural popularity far beyond that enjoyed in its original Malayan home.

If the Malayan varieties of the coco palm are to be accepted as proof of anything, it is that the wild ancestral type of the species has not existed in that part of the world during the period in which the diverse mutations have arisen. The relatively unmodified coconuts of America, on the other hand, may indicate the comparatively recent presence of the "unimproved" wild stock, and corroborate the evidence afforded by the geographical distribution of the related species of Cocos and the presence of the coco palm itself, in the salt-spring regions of the interior of Colombia.

The history of the coco palm has been discussed recently at some length by Professor De Vries as affording evidence that the numerous cultivated forms of the species have originated during the period of domestication and do not represent separate domestications of wild species or varieties already diverse. There could seem to be no question that this is true of the coconut as of other cultivated plants.^a

The inference to be drawn from the fact that *Cocos nucifera*, as now cultivated in the Old World Tropics and made up of a large number of very distinct varieties, is not that wild species are so constituted, but that domestication conduces to the formation of the diverse varieties. The wild plants show individual diversity, the cultivated plants varietal diversity. The individual members of wild species are generally more diverse than individuals of domesticated varieties. On the other hand, wild species seldom present any such measure of diversity as exists among domesticated varieties.

Trees of the larger varieties of the coco palm grow to a height of 50 to 100 feet, but a dwarf kind mentioned by Watt reaches a height of only 10 or 15 feet. The nuts differ correspondingly in abundance, size, and shape. In some varieties they are comparable in size to a man's head; in others to a turkey's egg. In shape they may be spherical or pointed at one or both ends, or with prominent angles. The outside of the husk may be green, yellow, red, bluish, brown,

^a De Vries, H., *Species and Varieties, their Origin by Mutation*, pp. 82-89. (Chicago, 1905.)

or black. On the inside the husk may contain coarse or fine fibers or may consist of a reddish edible pulp. The meat may be thick or thin, hard or creamy, and rich or poor in oil. One sort has an outer layer of the meat red instead of white. Finally, the varieties differ in size, number, and color of the leaves, some being light green and some dark, or yellowish, grayish, or reddish. Most kinds have the pinnæ separate, but in a few they remain united as in the young seedlings.

No wild palms have been found with any such individual or varietal diversification as the coconut varieties; indeed, most of the species of palms are less easy to distinguish from their nearest relatives than are these varieties. Professor De Vries has described many such variations of the evening primrose as new species, on the ground that they answer all the requirements of species as treated by systematists, but if this be true it would seem to be better to modify our taxonomic criteria than to set ourselves the unnecessary task of naming as new species all the cultivated varieties of coconuts and other plants.

The objection to the classification of these mutative variations as species is not that the amount of difference may not be as great as between some wild species, but that the evolutionary status of the mutation is not the same as among the wild species. The natural species is a group of freely interbreeding diverse individuals, while mutative varieties generally represent the progeny of a single individual variation, induced and maintained by inbreeding.

To give Latin names to fifty or a hundred Malayan mutations of the domesticated coco palms might appear to place them in the same taxonomic rank as the South American species of *Cocos*, but it would amount, after all, only to an assertion of the identity of conditions essentially unlike.

The Malayan varieties of the coconut are said to propagate true from seed with great uniformity, and this fact may have strengthened the idea of diverse ancestry in the wild state, but it is now known that the so-called mutations or abrupt variations of inbred domesticated plants, such as coffee, are often as constant in their characters as the parental type, or even more so. In this respect they often differ strikingly from new varieties, originated by hybridization, in which it is generally thought necessary to "fix the characters" by selection.

The coconut palm appears to be the only cultivated tree whose varieties are in the nature of mutations that come true from seed, if exception be made of the varieties of mangoes and citrous fruits that can be propagated from seeds because of the peculiar habit of polyembryony, the formation of false embryos from nucellar buds. The mutative varieties of the coffee shrub form a parallel with those

of the coconut, and some varieties of the peach also yield a considerable percentage of seedlings that retain the parental characters. The vast majority of varieties of cultivated trees have to be propagated from cuttings or grafts. The reason for this contrast between trees and annual plants is doubtless to be found in the greater amount of time required for the selective breeding of trees. The existence of mutative varieties might be considered as an evidence that the culture of the coconut palm is older than that of the date palm. That date varieties are usually propagated from cuttings should not interfere with the development of mutative varieties, but the dioecious habit of the date may be a more serious obstacle.

The evolutionary interest of the varieties of the coconut does not lie, therefore, in any difference of behavior from other plants of like history, but in their complete agreement, and in helping to show that even in plants so peculiar as the palms the same law of evolution holds, that narrow segregation, or inbreeding, is accompanied by mutative variations, often distinctly degenerate from the biological standpoint. The peach palm, the coconut, the oil palm,^a and the date have series of similar variations, indicating that like evolutionary causes are active in the production of like effects, in spite of the fact that the palms themselves and the conditions under which they live are very different.

Although the disparity in coconut varieties between the East Indies and tropical America is very great, it is a mistake to suppose that there are no distinct varieties in America. Velasco's account of the four different kinds of coconuts in Colombia has already been quoted, and reference has been made to the small variety found on Cocos Island by Professor Pittier as distinct from the ordinary commercial variety grown on the adjacent shores of Costa Rica. Mr. O. W. Barrett, who formerly resided in Porto Rico, states that there are two distinct varieties on that island, one with yellowish leaves and fruits, the other with green. The milk of the latter is considered preferable while the yellow variety has the thicker "meat." It is stated by planters and importers that the coconuts of the coast of Colombia, sometimes called San Blas coconuts, are considered different from those grown in other places in the Caribbean region. The ready separation of the meat from the shell gives these nuts a special value for manufacturing purposes.

A further example of what may be a distinctively American variety of the coconut was found in 1902 at Tapachula, a town in the

^a Preuss, P., *Ber. Deutsch. Pharm. Gesellsch.*, vol. 13, p. 109. 1903. Fendler, G., *loc. cit.*, p. 119. The latter paper describes three varieties from the Togo colony, the first with the shell so thin that it can be broken with the teeth, the second with green instead of red fruits, the third with the leaf segments united and the leaf bases persistent. See also The varieties of the oil palm in West Africa, *Kew Bulletin of Miscellaneous Information*, 1909, p. 33.

Soconusco district of southern Mexico. Instead of being oval or spherical, these nuts are strongly flattened on the very broad apex, so that the shape would be described in botanical terms as broadly obconic or turbinate. All of the nuts observed in the markets of Tapachula at the time of our visit in the spring of 1902 seemed to be of this type. They are also of distinctly larger size than those, for example, of Costa Rica. This fact may have caused them to be preferred for planting, but there is no probability that the peculiar shape has been secured by selection. The variety doubtless originated as a mutation or "sport," like those of the Malay region.

It is also reasonable to believe that the coconut was established on the Pacific coast of Mexico by human agency, as well as on the islands of the Pacific. There were Indian tribes of the Aztec family scattered along the coast at least as far south as the Nicoya Peninsula of Costa Rica, where many objects believed by archæologists to have been made in Mexico have been dug from prehistoric graves. The claim of some writers that the Indians of the Pacific coast of America are not navigators finds little support in fact, for all along between Alaska and Terra del Fuego there have been, even in the post-Columbian epoch, tribes with maritime skill and seafaring instincts. The Pacific coast of America from Mexico to Peru^a is dotted at frequent intervals with human remains which mark former centers of ancient cultural activity, many of them already decayed and forgotten before the Spaniards came, as the early explorers themselves had occasion to reflect.^b

ADAPTATIONS OF THE COCONUT FOR GERMINATION.

For nearly two centuries the coconut has been described in books of travel and natural history, and even in formal scientific works, as an example of a plant widely distributed in nature through the agency of ocean currents. Thus in a recent text-book:

The Coccoanut seems especially designed for floating, inasmuch as its outer fibrous husk forms a veritable life-preserver; it has been known to float hundreds of miles on the surface of the ocean. On reaching a strand, it readily germinates; in this way coral and volcanic islands in the South Seas are populated with Coccoanut palms.^c

^a The Indians of the islands off the coast of California, now extinct, are supposed to have been allied to the maritime tribes of British Columbia. The eminent American ethnologist Cushing maintained that a direct connection existed between the Peruvians and the ancient people who built the extensive irrigation canals of Arizona.

^b In ancient times these Indians were not natives of Quinbaya, but they invaded the country many times, killing the inhabitants, who could not have been few, judging from the remains of their works, for all the dense canebrakes seem once to have been peopled and tilled, as well as the mountainous parts, where there are trees as big around as two bullocks. From these facts I conjecture that a very long period of time has elapsed since these Indians first peopled the Indies.—Cieza de Leon, p. 89. (See footnote above, p. 287.)

^c Osterhout, W. J. V., *Experiments with Plants*, p. 325. (New York, 1905.)

Warburg includes *Cocos nucifera* in a list of "all-tropical shore-plants" (*Litoral-Pantropisten*) that have pronounced adaptations for swimming (*ausgepraegten Schwimmmanpassungen*). The adaptations are specified as "swimming-tissue in the husk and empty space in the kernel" (*Schwimmgewebe im Mesocarp und Hohlraum im Endosperm*).^a

It is true that the coconut is provided with a tough, fibrous husk from an inch to 2 inches in thickness which enables it to remain afloat for a long time. There is even a layer of wax on the surface, as though to render it impervious to water. A contrivance better suited for the maritime distribution of the nut would be difficult to imagine, and it is not surprising that writers who approach the subject from the standpoint of structure alone should continue to rely on apparently indubitable proof regarding the true habits of the plant in nature.

Unfortunately there appears to be no direct evidence to support these deductions from the structure of the coconut and its powers of floating. The same general type of husk is to be found among scores of other related species of palms, which do not grow on seacoasts and are not distributed by water. That the husk of the coconut is thicker than that of the other related species but comports with its larger size and the greater danger of breakage when it falls to the ground. The waxy coating of the surface is also no unique character, but is to be found in well-nigh the whole group of palms, the small fruits of many inland species being far more waxy than the coconut.

In the East Indies, where the culture of the coco palm has reached its highest development, nuts intended for planting are picked from the trees and let down carefully to avoid injury, even to the external coat of the husk. The breaking of this is thought to reduce materially the chances of successful germination. To permit the husk to dry out or to become infected with putrefactive bacteria or fungi might be equally dangerous for the young plant.

The unique habit of the coconut of preserving a store of water in an interior cavity of the seed is in itself an indication that the species was native in some relatively dry interior region where the regular supply of moisture from external sources would not suffice for germination. These extensive provisions for water storage would seem superfluous in a maritime plant able to draw moisture from sandy beaches wet twice a day with tidal brine. The distance to permanent moisture on a sandy ocean beach is very short; in fact, the sand is never really dry at all except at the surface. For a plant able to thrive on a salt solution, a covering of an inch or two of sand

^a Warburg, O., Einige Bemerkungen Ueber Die Litoral-Pantropisten, Annales du Jardin Botanique de Buitenzorg. Supplement II, p. 133. 1898.

would be a sufficient permanent protection against drying out. It is only when we think of the coconut as growing in an alkaline interior region, subject to prolonged drought, that we can appreciate the large hollow seed and the very thick husk as characters that give the palm special adaptation to the natural conditions of its environment.

The very large size of the coconut, which is the largest of all seeds except one,^a undoubtedly tends to keep it from becoming buried in the ground, and would thus interfere seriously with germination if it were not for the fact that the young plant sends its first roots into the fibrous material of the husk, which serves as a sponge for the storage of water. By virtue of its husk the coconut is able to proceed with germination without waiting to be buried in the ground.

Palm seeds are notoriously short-lived, with very little of the usual power of seeds to remain dry and dormant for long periods of time. If palm seeds are very carefully packed so as to keep just the right amount of moisture, enough to prevent drying out but not enough to permit germination, they can often be kept for several months; otherwise a single drying may be fatal. The seeds of many species have a natural packing in the form of a fleshy external pulp like the date, able to hold moisture by reason of the sugar it contains.

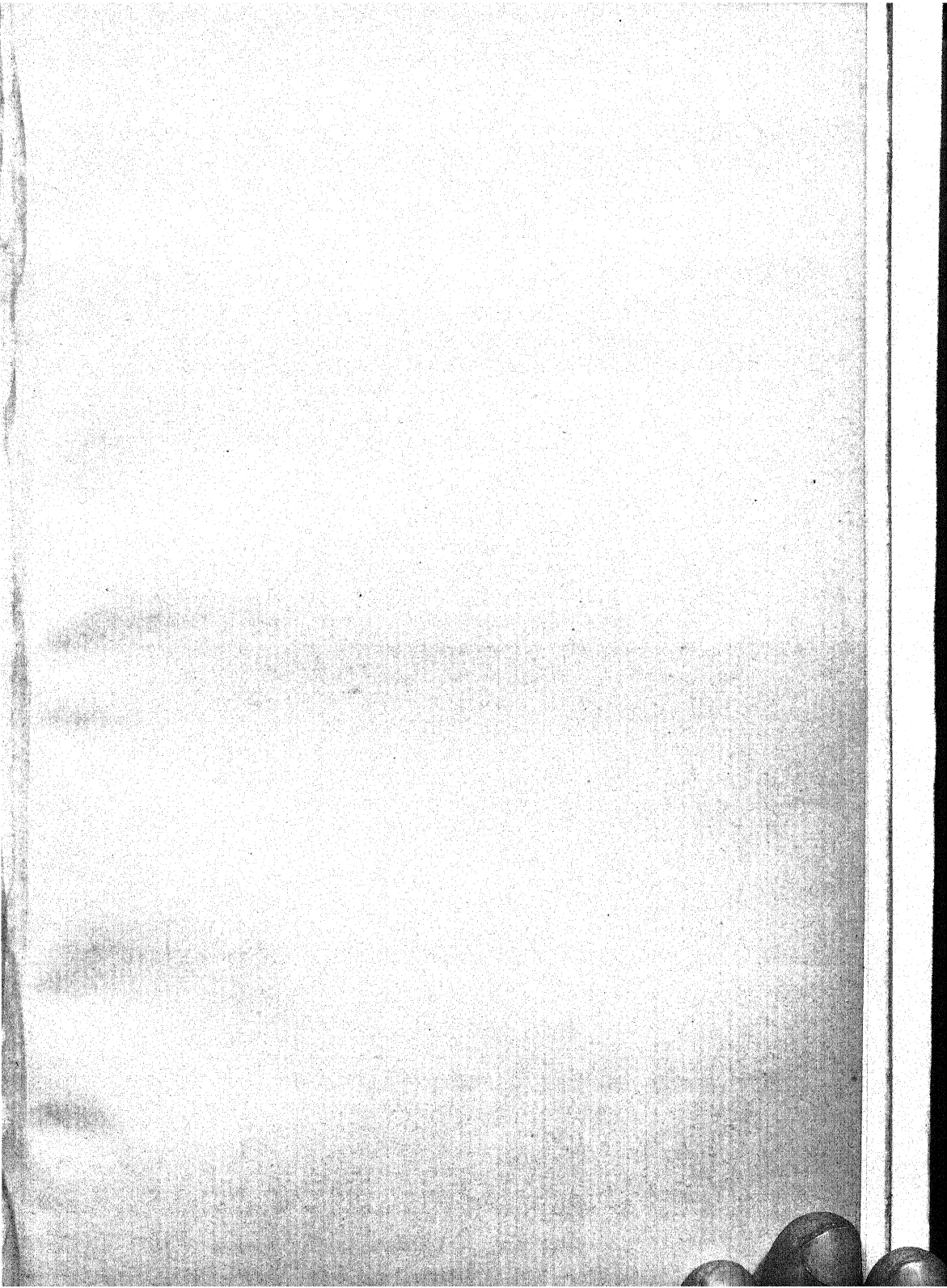
But with most palm seeds early germination is a necessity and if, as often happens, the fruit ripens in the dry season,^b germination becomes a very critical problem for which many specialized solutions have been worked out in the various natural groups of palms. And even if the germination can be deferred until the rainy season the next period of drought may find the young plants still very small, for the palms labor under the further disqualification of very slow growth, especially in their earlier stages.

The process of germination is extremely slow in the palms. The embryo is very small in comparison to the hardened food materials which have to be digested and absorbed into the tissues of the seedling. Long before any external sign of germination appears there is a growth of the cotyledon, or absorbing organ of the embryo, at the expense of the hardened food materials stored in the seed. In the

^a The so-called double coconut, or coco-de-mer *Lodoicea maldivica* (L.), a huge fan palm native in the Seychelles Islands of the Indian Ocean, has seeds several times as large as coconuts. A single fruit of *Lodoicea*, containing three or four seeds, sometimes weighs from 40 to 50 pounds.

^b In India the hot, dry months are counted upon to bring the nuts to maturity.

"In six months from blossoming, the kernels of the nuts begin to solidify; in a year, the fruit is fully ripe—even sooner if the season is very hot and dry. The produce of the tree in full health and properly tended is much dependent on soil and climate. The average may be put down at 120 nuts in the twelve months; in a low and sandy soil, it will amount to 200; in gravel and laterite, not 60. The most productive months in India are from January to June, that is for ripe nuts, the heat bringing them quickly to maturity."—Spons' Encyclopedia.



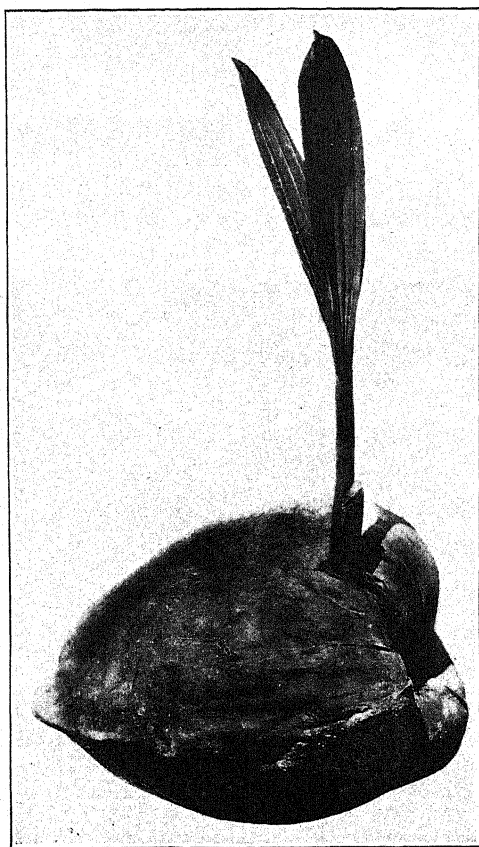


FIG. 1.—GERMINATING COCONUT.

The young plant shows one bladeless leaf sheath and one simple, deeply divided leaf. (Reduced.)

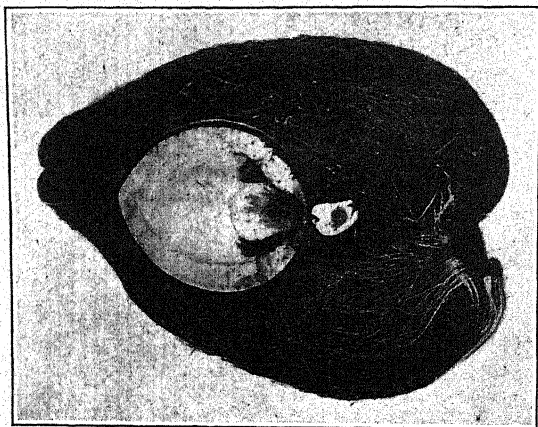


FIG. 2.—CROSS SECTION OF COCONUT GERMINATING INSIDE THE HUSK.

From Prudhomme, *Le Cocotier*, fig. 31, p. 105 (Paris, 1906). (Reduced.)

case of the coconut the embryo lies inside the largest of the three thin spots or "eyes" at the base of the shell, and the soft spongy cotyledon grows out from this point to fill the whole interior cavity of the nut and then continues to digest and absorb until all of the surrounding food materials have been taken over and conveyed into the growing parts of the young plant.

Palm seeds with thick hard shells like the coconut are provided with special channels or pores for the exit of the embryo, covered only by a thin scale of the shell material or a specially formed lid or plug easily pushed out of the way. When germination finally occurs the base of the cotyledon grows out of the seed, carrying with it the plumule or leaf bud of the young plant, which later emerges from the cotyledon by a split on one side.

With the relatives of the coconut, which have not thick husks, the second phase of germination, the escape of the young plantlet by the opening of the cotyledon, necessarily takes place outside the husk, but with the coconut the whole process of germination may be completed inside the husk. Coconuts buried in the moist soil germinate without any special assistance from the husk, and even without waiting for the cotyledon to grow to full size by absorbing the food materials of the endosperm. It is said to be customary in some localities to remove the husk before planting. But if the husk is allowed to remain intact the coconut is able to germinate without even being placed in the ground. And not the germination alone, but the subsequent growth of the young plant may go on for months without any external contacts, the leaves often attaining considerable size before the roots have made any external growth beyond the fibers of the husks. The young coconut seedling, with its ample provision of food and moisture and its fibrous husk for the accommodation of its roots, might be described as a self-potted plant. It is to a very large extent independent of external conditions during the early stages of growth, which are much more precarious for all other palms. The preference of gardeners for coconut fiber as a potting material may be accepted as a testimonial of the success of the palm in meeting the needs of the seedlings. (Pl. 59, figs. 1, 2.)

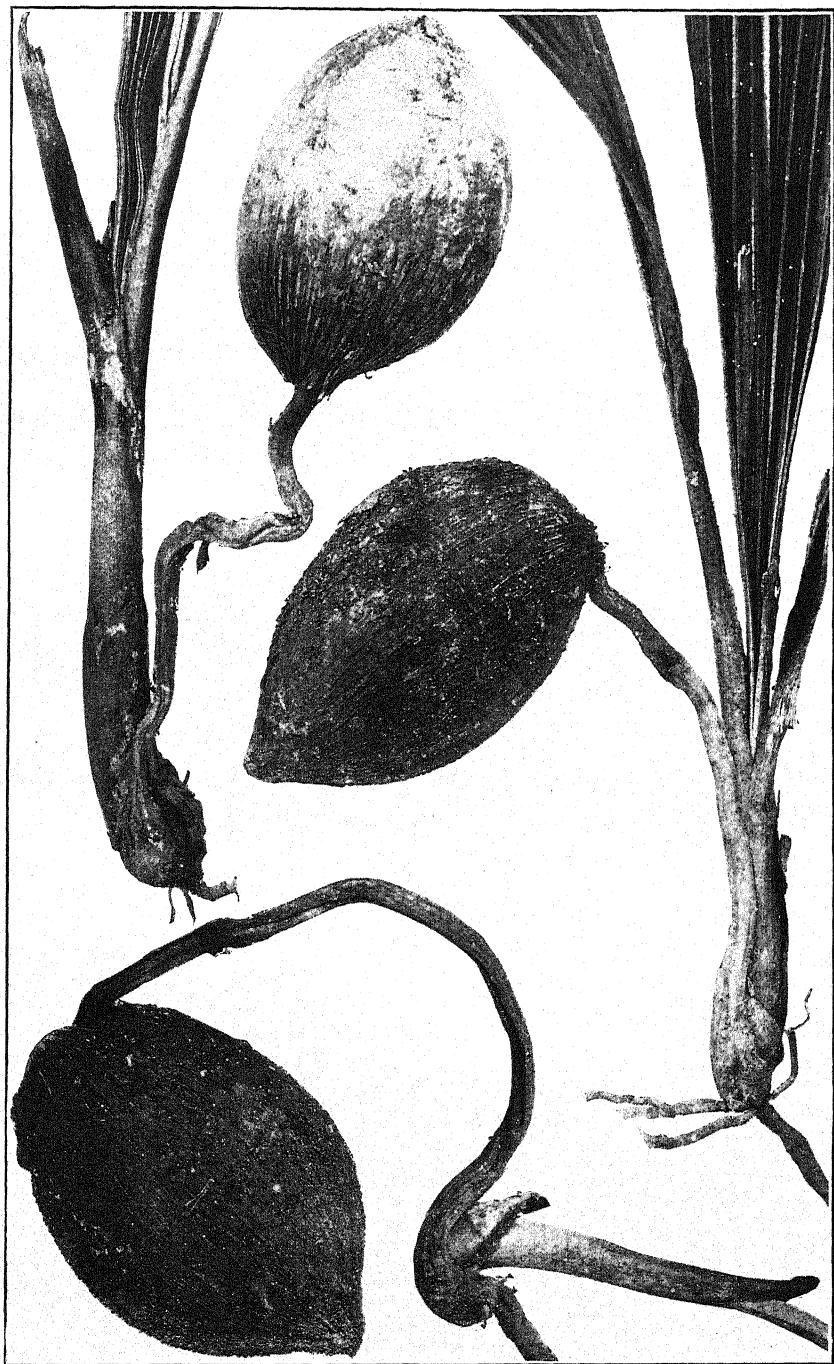
For palms that are natives of humid, densely forested regions such a provision would be superfluous and disadvantageous, for with them it is a question of increasing the number of seeds and seedlings and of thus multiplying the chances that some of the seedlings will find favorable situations, with light enough to permit them to grow. Natural selection in the form of competition of other vegetation would discriminate against the evolution of an excessively large seed in a species tolerant of shade. But for a palm that lives in an open country with long, dry seasons, the protection of the seed and the

seedling against drying out would be of the greatest possible advantage. An evolutionary tendency in this direction would be favored by natural selection and might be expected to make rapid progress. The natural result would be that we should have one species highly adapted in one respect, but remaining otherwise closely like its relatives, as in the case of the coconut. The adaptive value of the husk as an expedient for germination can also be estimated by comparing the habits of the coconut with those of related palms that encounter similar environmental problems.

Excellent examples of adaptive germination devices are afforded by *Attalea* and *Acrocomia*, two relatives of the coconut found in Guatemala. The seeds of *Attalea cohune*, which abounds in eastern Guatemala, are about the size of a turkey's egg, with a thin woody husk and an extremely hard, bony shell almost half an inch in thickness, perforated at the base for the exit of the embryo. But instead of pushing out a young plant as in the coconut, the first organ to emerge from the seed is the long, slender, cord-like cotyledon, which grows down into the ground for a distance of from 3 to 6 inches (pl. 60). The true germination takes place at the end of this burrowing organ, so that the young plant, though produced from a seed lying on the surface of the soil, is well and deeply planted, and at once sends its roots still farther down to establish communication with the permanent moisture of the deeper layers of the soil. The cord-like cotyledon connecting the seed with the young plant remains alive for a long time, to carry down food materials from the storehouse above.

In *Acrocomia* the same difficulties have been solved in a very different way, though not less definitely adaptive. The nursing foot or cotyledon is very short and remains functional for a much briefer period than in *Attalea*. The young plant completes its germination and begins its development close to the surface of the soil. It partially supplies the deficiency of the length of the cotyledon by growing downward at first instead of upward, the bases of the leaves being abruptly bent (pl. 61). These first joints of the seedling very soon thicken into a fleshy bulb, formed, doubtless, by a prompt transfer of the nutrient material stored in the seed, thus avoiding the need of a long-lived cotyledon as in *Attalea*.

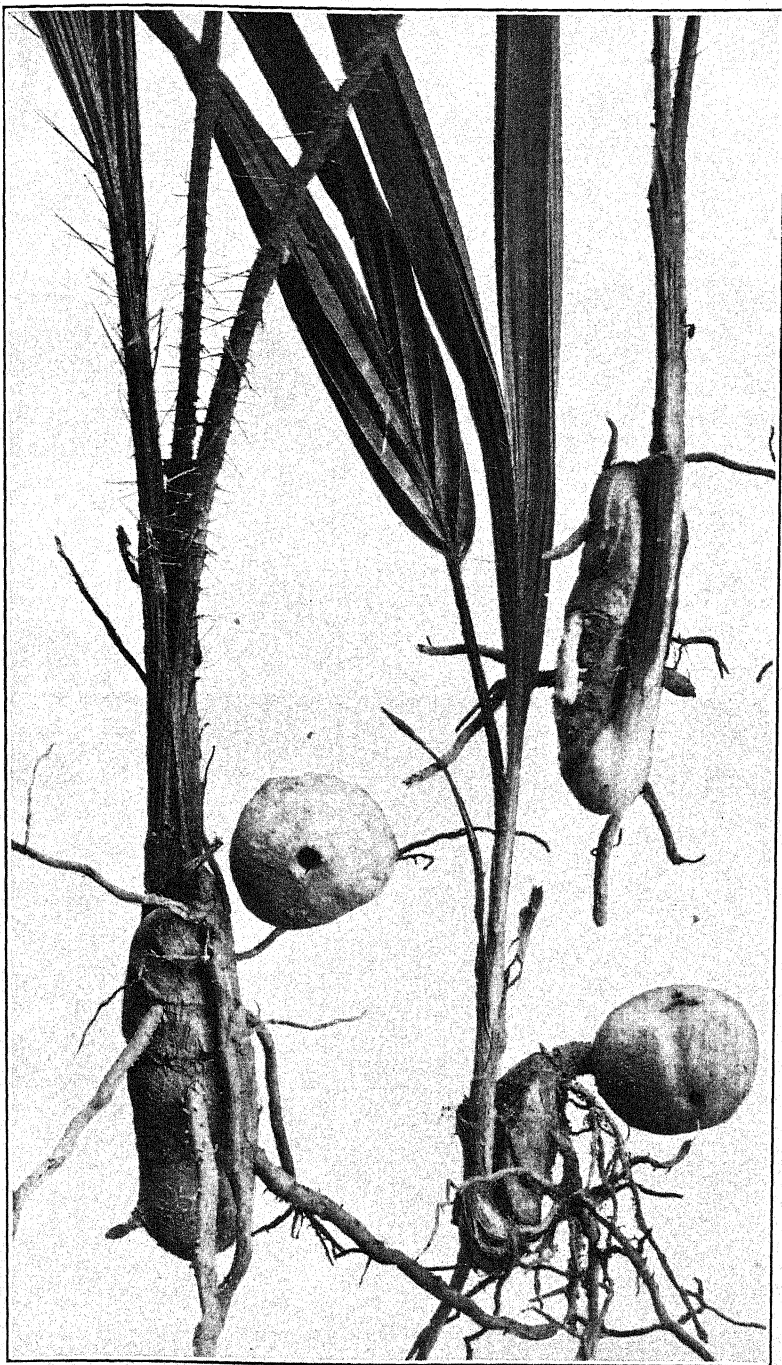
The coconut follows neither of these policies. Being provided with its own water supply inside and outside the nut, it is able to grow a plant of considerable size before attempting to make any connection with the soil. And then being thoroughly prepared, and the proper season having arrived, it is able to send down a good supply of roots to the level of permanent moisture in the soil and establish itself on a self-supporting basis.



GERMINATION OF THE COROZO PALM (*ATTALEA COHUNE*).

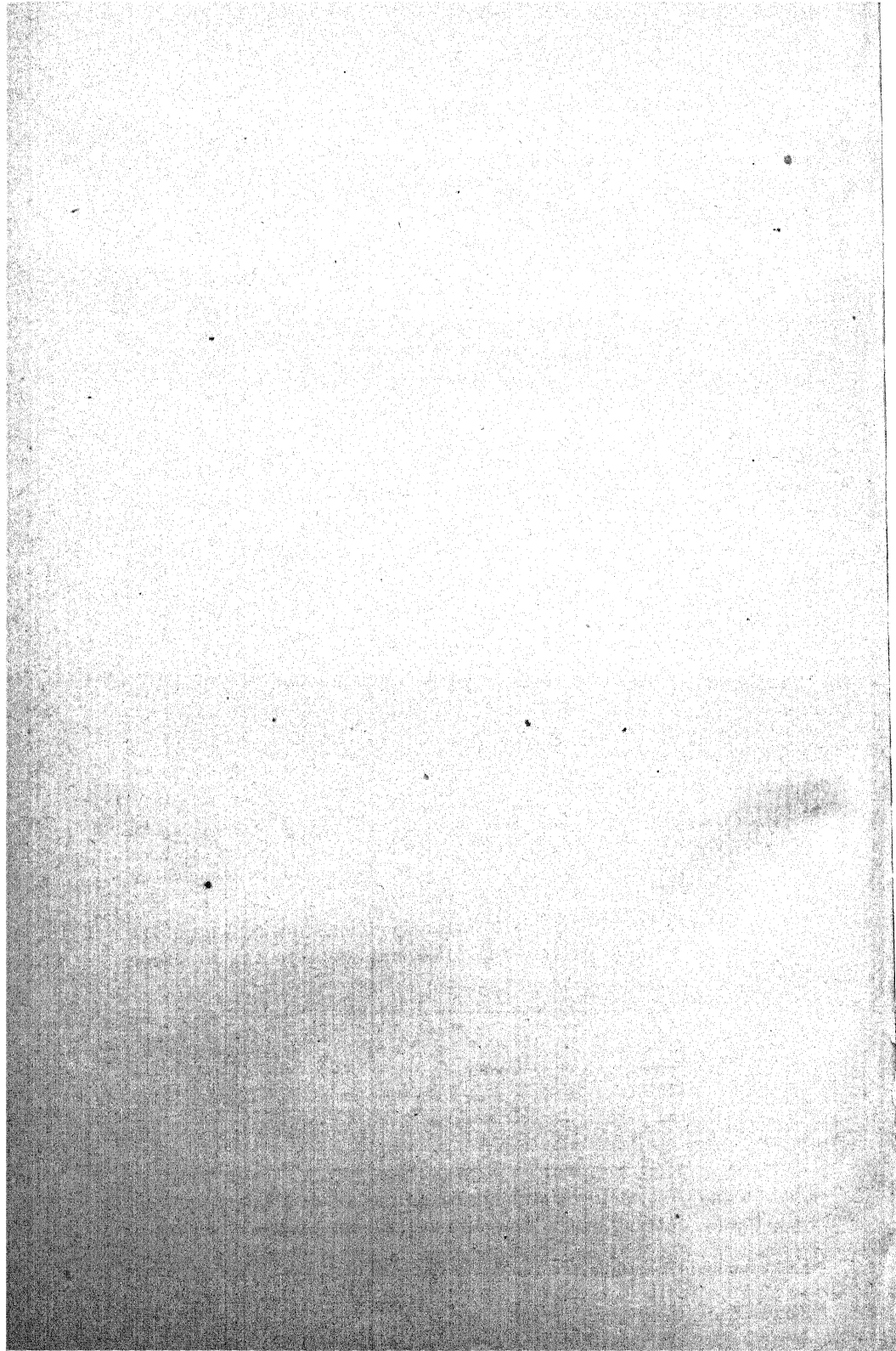
Showing the long burrowing cotyledon that carries the embryo into the ground. For comparison with the germination of the coconut as shown in plate 59. (Natural size.)





GERMINATION OF THE COYOL PALM (*ACROCOMIA VINIFERA*).

Showing the nuts with their foramina, the very short cotyledon, and the downward growth of the stem of the young cotyledon to form a fleshy subterranean bulb, producing the first leaves from its lower end. (Natural size.)



Even when actually hung up or kept in the house coconuts will often germinate and grow a plant 2 feet or more in height. In fact they often do much better when treated this way than when buried in the ground too soon, and it is the regular custom in some tropical countries to germinate coconuts in sheds before planting them in the ground.

Nevertheless it is difficult to believe that the moisture of the nut and its husk can sustain the plant for so long a period. The possibility that atmospheric moisture is drawn upon to replenish the supply may be worthy of consideration, though it seems not to have been regarded in studies of the germination of the coconut. Thus Kirkwood and Gies declare:

Neither the husk nor the shell appears to serve any other than passive mechanical function, and only the constituents of the endosperm and milk, so far as the nut is concerned, nourish the young plant before it finds in the soil the elements provided there in abundance for its growth to maturity. . . .

The lowest part of the stem contains almost as little solid matter and is nearly as watery as the cotyledon. The percentage of water in the stem diminishes as the distance away from the "root crown" increases. The watery condition of the lower part of the stem is increased, doubtless, by the fact that the surrounding husk is impregnated with water, thus favoring direct absorption by osmosis and at the same time preventing evaporation from the surface of the growing tissue.^a

But on a previous page these writers have referred to chemical analyses which support in a striking manner the suggestion that the husk of the coconut may be able to collect moisture for the benefit of the young plant, and that it is the husk for which the plant makes demands of salt and potash.

Bachofen's results indicate that sodium chloride and potassium phosphate are the chief inorganic matters drawn upon in the development of the cocoanut—chemical data in harmony with the fact that the cocoa palm does not thrive away from the coast or where salt is lacking in the soil.^b

A summary of Bachofen's analysis is also given, showing that of the important ingredients of the soil 1,000 nuts remove the following quantities:

	Total in pounds.	Portion in husk.
Nitrogen	8.65	3.70
Phosphoric acid	2.45	.84
Potash	18.75	13.52
Lime	2.30	1.82
Sodium chloride	21.42	20.23

This means that each coconut husk contains about a tablespoonful of salt, to say nothing of the lime and potash, the presence of which

^a Kirkwood and Gies, Bulletin of the Torrey Botanical Club, vol. 29, pp. 352, 357. (1902.)

^b Kirkwood and Gies, loc. cit., p. 334.

may well assist in increasing the power to attract and hold water for the young plant.

The more we appreciate the highly specialized adaptive characteristics of the coconut the more unwarranted appears the idea of maritime distribution. The huge size of the nuts and the necessary limitation of their number, would have no meaning from the standpoint of maritime distribution, the maximum production of flourishing trees under favorable conditions being reckoned at only 200 nuts. Related palms comparable in size to the coconut, such as *Attalea* and *Acrocomia*, produce seeds in vastly greater numbers. The number of pistillate flowers is relatively very small in the coconut palm and many of these are abortive (pls. 62, 63, 64). It would be impossible for any large number to develop. The chances of any sea-borne nut floating to a favorable destination are so infinitesimal that the natural perpetuation of the species by this method would be entirely impracticable. The specialization of the coconut toward greater size is in itself an evidence that natural selection has favored this tendency. If a few large seeds had not been more advantageous to the palms than many small seeds we may be sure that the large seeds would never have developed. How important the factor of human selection may have been we do not know, but it does not appear that larger size has been a desideratum. The largest varieties do not seem to be specially preferred in cultivation.

BEHAVIOR OF THE COCONUT PALM IN INTERIOR LOCALITIES.

The popular impression that the coconut will grow to normal maturity only in the immediate vicinity of the ocean has arisen from the fact that this palm, like the date, is a salt-loving plant and in continuously humid tropical countries finds no congenial soil except near the seashore. Many agricultural treatises and general works of reference continue to repeat the traditional theory of direct and necessary connection between the coconut and the sea. Even Nicholls asserts the limitation to the seacoast.

The climate, however, must be a maritime one, the palm delighting in the saline atmosphere of the seacoast. When the tree is planted inland, in order to make up for the want of a saline atmosphere, it is usual to put salt in the holes before the seedlings are set out, and as much as half a bushel of salt is sometimes used in this way for each tree.^a

But this view is no longer universal, and is very definitely denied by a recent writer on coconut culture in British India.

The old idea that it would not thrive far from the influence of the sea breeze is exploded, as it grows well all over the low country, where the soil and rainfall are suitable, and even in sheltered valleys at an elevation of 2,000 feet, as in the town of Badulla.^b

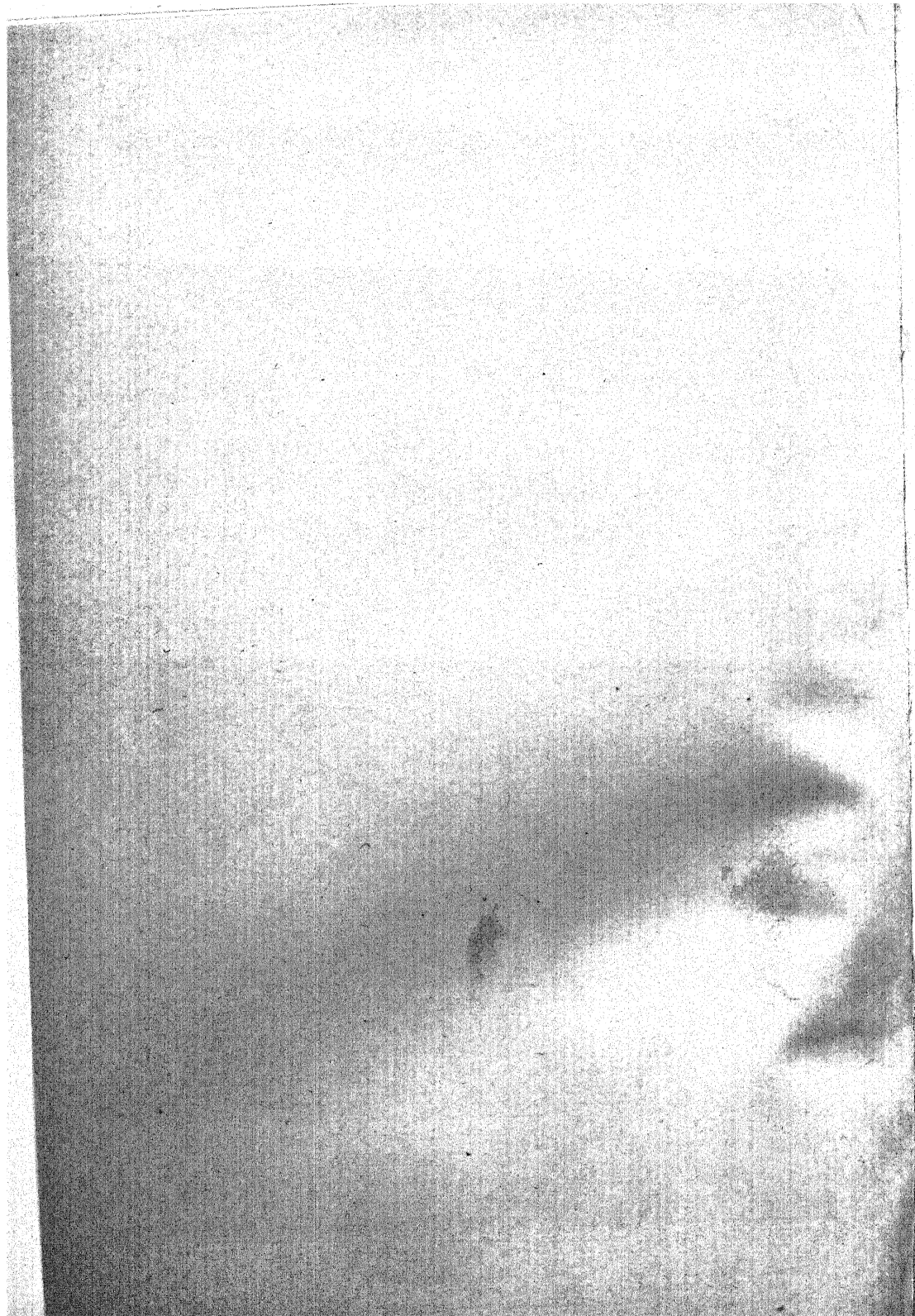
^aNicholls, H. A. A., *Tropical Agriculture*, p. 167. (London, 1900.)

^bJardine, W., *The Cultivation of the Coconut Palm*, *Tropical Agriculturist*, vol. 24, p. 151. (1905.)



FLOWERS AND FRUIT OF A YOUNG COCONUT PALM, BELIZE, BRITISH HONDURAS.

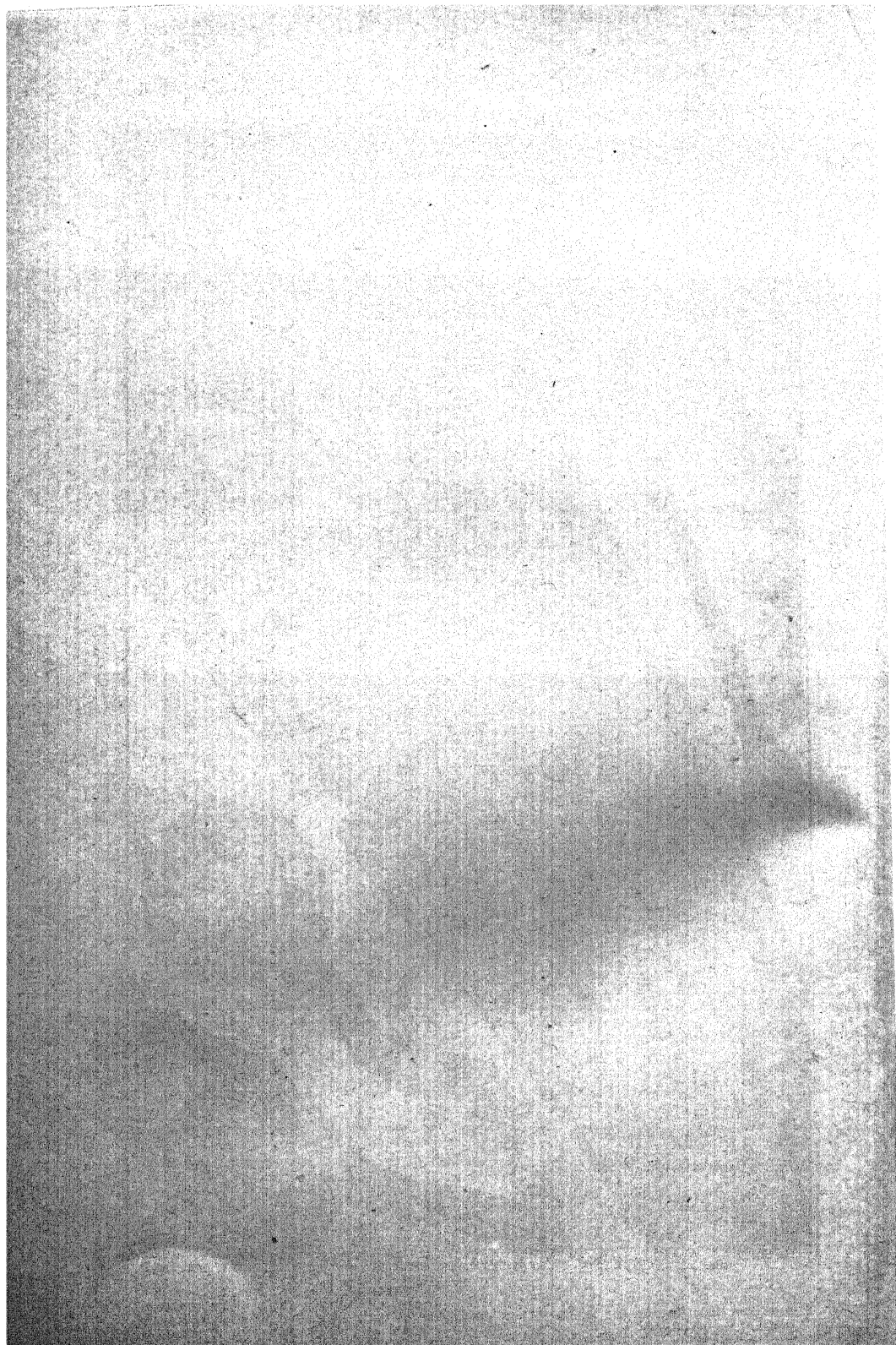
The fibrous leaf sheaths and tubular spathes that inclose the inflorescences when young are also shown, as also the scars of the bases of fallen leaves on the trunk.

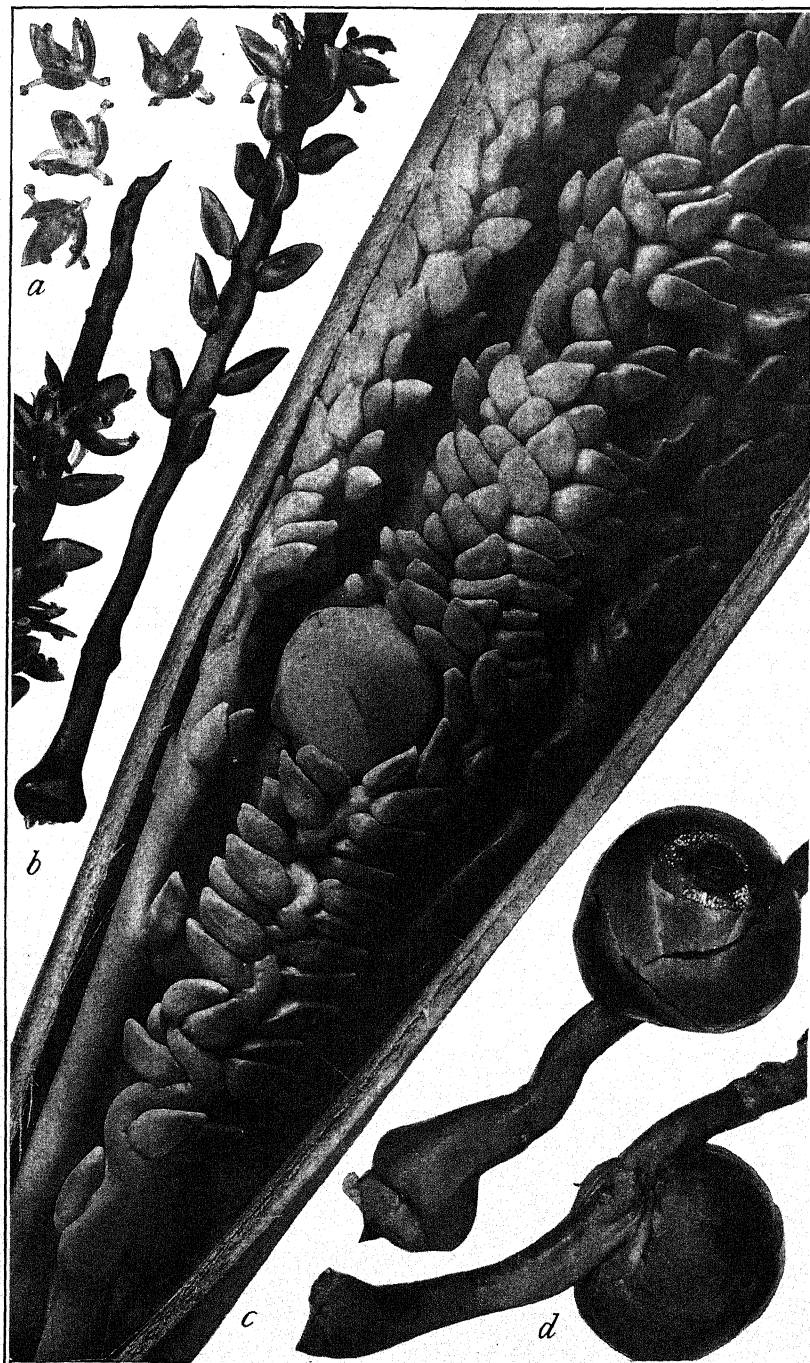




FRUIT CLUSTERS OF MATURE COCONUT PALM, COSTA RICA.

In a banana plantation at La Colombiana, near Port Limon. More productive trees are sometimes seen, but this gives a fair impression of the clusters of nuts as they hang in their natural position.





INFLORESCENCE OF THE COCONUT PALM, WITH STAMINATE AND PISTILLATE FLOWERS.

a, Four staminate flowers; *b*, base and tip of a branch of an inflorescence, with staminate flowers; *c*, part of a spathe enclosing the inflorescence, with numerous buds of staminate flowers and one pistillate bud; *d*, bases of two branches, each bearing a very young coconut. (*a-d*, Natural size.)



The traditional partiality of the coconut for the seabeach is fully explained by two considerations, the salt and the relative absence of other vegetation, which enables it to be grown with less care or to persist longer without cultivation. The limestone of coral islands may also afford sufficient alkaline matter for the coconut, even out of reach of the sea water, as described by Wallace on the island of Matabello in the Malay Archipelago.^a

Nor is the coconut confined to humid tropical climates or to low elevations. Coco palms have been reported as thriving away from the sea in relatively dry localities in several tropical countries. Pickering reported them in Arabia in the district behind Muscat. Coconuts are extensively grown in the southern part of the Hindustan peninsula, and even in Bangalore, in the middle of the peninsula at an altitude of 900 meters. Field cultures of coconuts are recognized as acutely dependent upon particular kinds of soils.^b

An old report of coconuts in the interior of Africa, in the region of Timbuctu, was probably a mistake, as Seemann has pointed out, though it does not appear improbable that they would grow there if planted. Landor refers to five kinds of palms as seen about Timbuctu, but makes no mention of coconuts.^c

^a "The natives of Matabello are almost entirely occupied in making cocoa-nut oil, which they sell to the Bugis and Goram traders, who carry it to Banda and Amboina. The rugged coral rock seems very favorable to the growth of the cocoa-nut palm, which abounds over the whole island to the very highest points, and produces fruit all the year round."—The Malay Archipelago, p. 281. (London, 1889.)

^b A report "On the composition of Indian soils" contains the following statements: "No. 375-96. Black loam; lies on a gravelly substratum at a depth of 2 or 3 feet; is therefore unfit for cocoa-nut. The ryots complain that the soil of this and the neighbouring fields is not retentive enough, and needs to be more frequently watered than the fields farther down the Cauvery Valley. Irrigated under the Kaling-arayan channel from the Bhavani.

"No. 377-96. Clay, black; more mellow and clayey than No. 375. At a depth of 3 to 5 feet there is a bed of impalpable black sand; cocoa-nuts and plantains thrive on this remarkably, and nowhere in the Cauvery Valley are cocoa-nuts more extensively cultivated. The nuts are comparatively small. (The sample received could not be called either black or clayey; it consisted of a dark-brown loamy soil.)"—Leather, J. W., The Agricultural Ledger, No. 2, p. 8. (1898.)

^c "A few date palms, the *gorboy-musukuru*, the *gorboy-homo*, with long green thorns and a bitter fruit much enjoyed by the children, and a number of dwarf palms are to be found, as well as the forked palm, *thebaide*."—Landor, A. H. S., Across Widest Africa, vol. 2, p. 451. (1907.)

The palms with the long green thorns may be oil palms, *Elaeis guineensis* Jacq., which have the lower pinnae narrow, stiff, and spine-like. Many other palms have spines along the margins of the petioles, but usually short and brown or black in color. The fruits of *Elaeis* are rather bitter when raw, but not after they have been roasted.

A recent publication on the German colonies contains a photograph of a group of apparently thriving coconut palms at Misahoehe, in the interior of the Togo colony in West Africa, but no statement is made regarding them.^a

Coconut palms are grown in large numbers on limestone soils in interior districts of the Yucatan peninsula, especially about the city of Merida, and they are also said to thrive on the Pacific side of Mexico, around the volcano of Colima. They are also reported by Mr. G. N. Collins at Acala, a town in the State of Chiapas, in an arid interior district with a natural growth of cacti and other desert plants.

Humboldt remarked particularly the vigorous condition of the coconut palms found by him in the interior of Venezuela and Colombia, which he considered as an anomalous fact in the distribution of a maritime species. Sir Richard Burton mentions the coconut palm as flourishing and very productive in interior districts of Brazil that have alkaline soils which he recognized as a practical substitute for "sea air."^b

More recent testimony to the existence of the coconut palm in interior localities of South America is that of Prof. H. Pittier, a special agent of the Department of Agriculture, who makes the following statement:

Until 1891, I had no notion of that species bearing fruit at any great distance from the seashore or high above the sea level, but when, on behalf of the Intercontinental Railway Commission, I crossed the Azuero peninsula from Remedios to Santiago de Veragua, in the present Republic of Panama, I was surprised to see groves of coconut palms surrounding the houses in the high savannas of Tolé, more than 365 meters above sea level. The sites of many houses in the valley of Tabasará were marked by isolated coconut trees. This, however, did not seem so very wonderful on account of the proximity of the sea, and at Tolé the inhabitants attributed the fine condition of the palms to their being fully exposed to the sea breeze. But in 1905, when we entered through Buenaventura into the Dagua Valley of Colombia, we began to notice coconut trees as soon as we reached the drier region of the interior, at an altitude of over 2,000 feet. On the inner watershed of the Western Cordillera, near a hostelry and on the brink of a precipitous slope, another beautiful specimen was found at about 4,800 feet above sea level. In the Cauca plain, in the interior of Colombia, at a mean level of over 900 meters, in a warm, temperate climate, with extreme conditions of wet and dry seasons, groves of coconut palms were seen everywhere. (Pl. 66, fig. 1.) The people of the Cauca Valley did not seem to distinguish their variety from the one growing on the seashore at Buenaventura, but Dr. Evaristo García, a noted naturalist and physician of Cali, assured me that coconuts brought into the valley from the seabeach do not thrive.

In the Cordillera de Santa Marta I have seen several coconut trees on the hills around San Andrés at nearly 1,090 meters of elevation, and the palm seemed to be quite familiar to the Indians. All over Central America the coconut palm is also

^a Wohltmann, F., *Kultur-und-Vegetations Bilder aus unseren Deutschen Colonien*, pl. 52.

^b Burton, R., *Highlands of Brazil*, vol. 2, pp. 264, 280. (London, 1869.)



FIG. 1.—COCONUT PALM, NEAR PALMIRA,
CAUCA VALLEY, COLOMBIA.

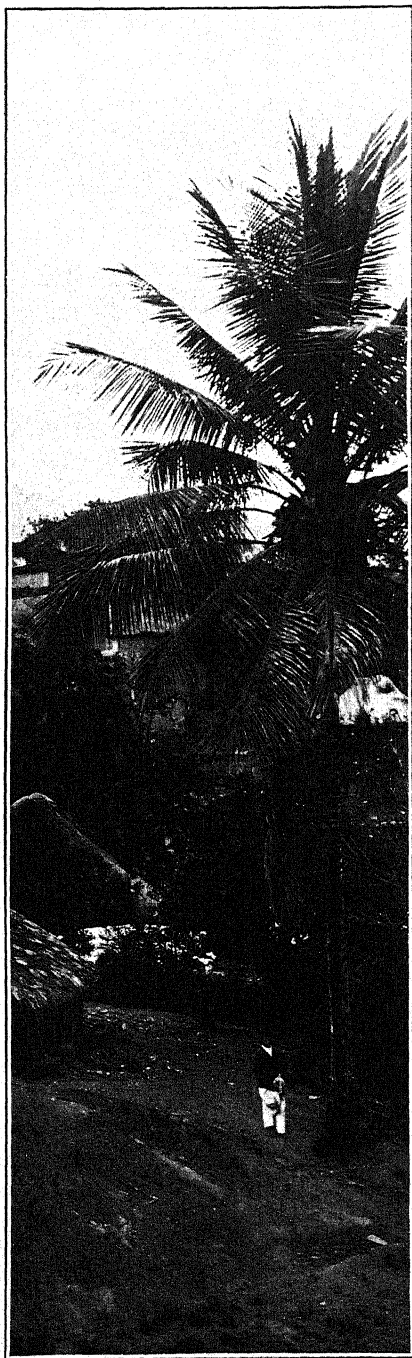
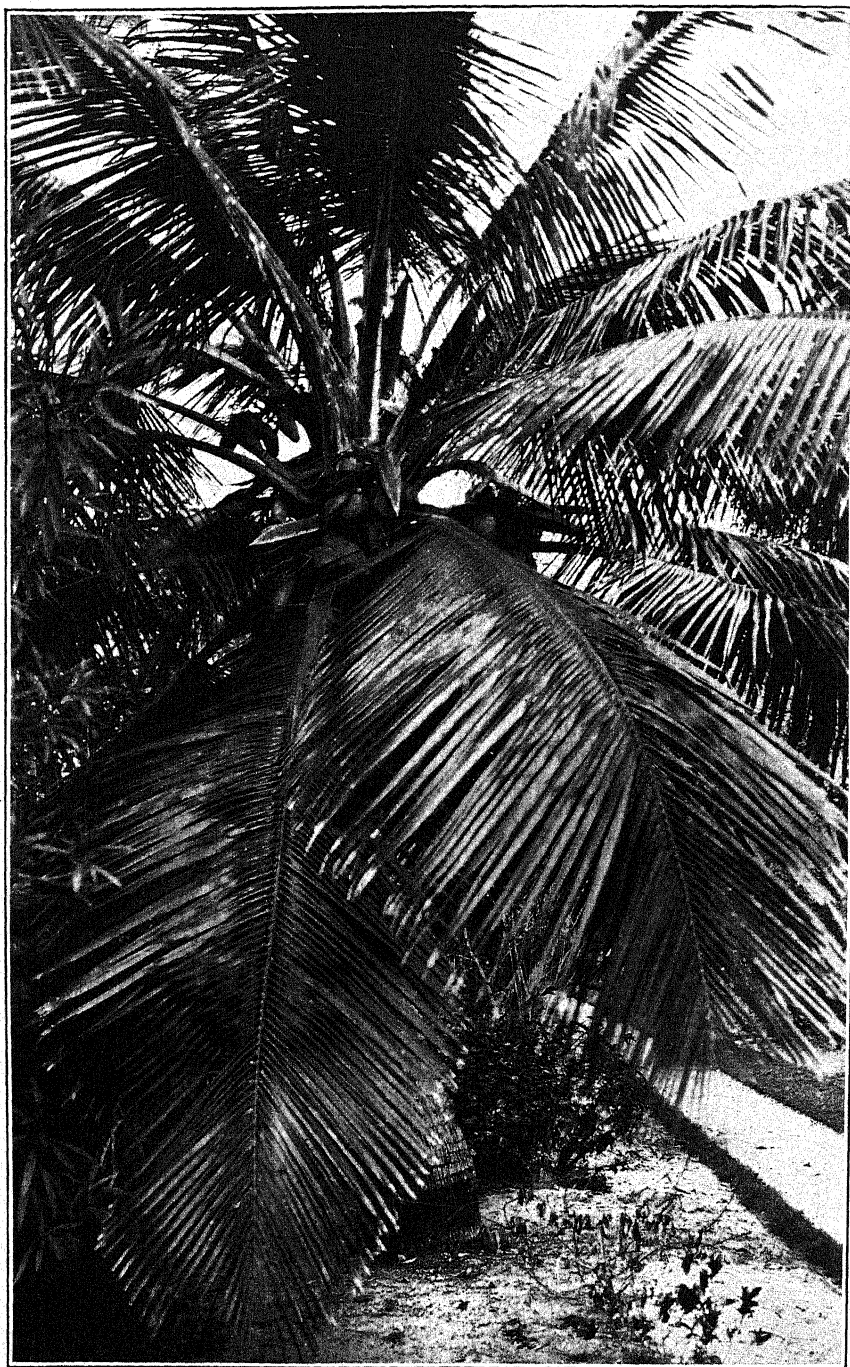


FIG. 2.—COCONUT PALM AT CAJABON,
ALTA VERAPAZ, GUATEMALA.

Examples from interior localities. Fig. 1, altitude 900 meters; fig. 2, about 360 meters.



COCONUT PALM AT BELIZE, BRITISH HONDURAS.

Showing wide form of leaves as presented under sea-level conditions. To be compared with plates 52, 65, which show palms growing under interior conditions and having stiffer and narrower leaves.

frequently cultivated in the interior, especially in the drier districts, but the natives do not seem to be so well acquainted with it as is the case in South America, and they have no special names to designate it.

The palms shown in plate 52 (frontispiece) are growing in the city of Salamá near the geographical center of Guatemala. The broad valley or plateau in which Salamá is situated has an altitude of 900 meters, and has a distinctly desert climate, but the coconut prospers apparently as well as on the seashore. The leaves are not as large as usual in coast-grown palms (compare with pl. 65), but this is in accordance with a very general principle of plant growth, that plants produce smaller leaves under the stronger light and more rapid transpiration afforded by desert conditions.

The coconut is also planted with success in other dry valleys in Guatemala, notably in that of Cajabon (pl. 66, fig. 2). It is a curious fact that in several of these places the prosperity of the palms is coincident with the prevalence of goiter, a disease commonly supposed to be associated with alkaline water, which might be an advantage to the palms.

In eastern Guatemala, near Livingston, the coconut palm has given an apparent illustration of its requirement of salt by refusing to grow within a few rods of the ocean on slopes moistened only by fresh water. The nature of the soil and the water supply will probably be found to constitute a very large factor in all such cases. The palms thrive much better in the town of Livingston, built on a part of the same slope where the agricultural production of coconuts appears to have failed (pl. 54, fig. 2, facing p. 299). Proximity to the sea is not enough without the right conditions of the soil. Other tropical tree crops, such as coffee and cacao, often thrive under dooryard cultivation in districts where agricultural production is much less successful. Even at Panzos, 90 miles from the sea, coconuts are still able to grow in the yards about the houses.^a

The dryness of the interior valleys of Guatemala, and the alkalinity of their scant water supplies, are to a large extent artificial conditions induced by the long-continued presence of agricultural populations and the consequent destruction of the forests and denudation of the

^a An instance where proximity to the sea enabled palms to thrive in otherwise unfavorable soil is given in Spons' Encyclopedia:

"Coco-nuts growing in mangrove soil on the side of creeks, and more or less saturated with salt, have their milk brackish, and the sap is saline also. These trees do not suffer from the attacks of the rhinoceros beetle, and are found to bear much sooner than those planted on a sandy soil. As an illustration of this, while trees planted at Penang thirty years ago, on sandy soil, have not yet borne fruit—although they are fine-looking trees—others in the same plantation, only 10 years old, but on low ground, where the sea tide comes up daily, washes their roots, and runs off again, are in full bearing, giving 50—100 nuts annually, and the kernel is as thick as that of nuts grown on sandy soil, and produces as much oil."

soil. Under favorable conditions upon the seabeach the coconut palm may require only one form of assistance from man—protection against the shade of other vegetation—but in other places it may become dependent upon man for its water supply and for the saline constituents of the soil.

ABSENCE OF COCONUT PALMS ON THE COAST OF PERU.

The failure of archæologists to find coconut shells in the ancient graves of Peru was used by De Candolle as an argument against the American origin of the palm, but coconuts still refuse to grow along the Peruvian coast, in spite of efforts to introduce them. Other palms flourish in the botanical gardens at Lima, but numerous experiments have shown that the coconut is entirely unsuited to the local conditions. Although much of the coast belt of Peru lies inside the Tropics, the sky is overcast and the weather continuously cool for several months of the year, a result of the cold Humboldt current that follows the Peruvian coast. The unfavorable climate continues northward nearly to Guayaquil, where the cloud belt is passed and the coco palm thrives.^a

The English botanist Spruce, who made a special study of the vegetation of this region, considers that the Peruvian desert extends along the coast even farther north than Guayaquil, almost to the equator, his first mention of coconuts growing on the coast being at 1° 5' south latitude.

The northern limit of the Peruvian desert is usually placed about Tumbes, at the southern extremity of the Gulf of Guayaquil, in latitude 3° 30' S., but I now know, from personal inspection, that the coast of the Pacific north of the gulf has the same geological conformation, the same climate, and almost as scanty a vegetation as it has south of it. At what point to northward the struggle between barrenness and fertility begins to be equally balanced I am unable to say, but I am inclined to place it about Cape Pasado, at the mouth of the river Chones. Guayaquil itself, as seen from the river, with its groves of coco palms and fruit trees, and its picturesque wooded hills, might be supposed a region of forests; but the moment we pass the skirts of the city to westward we find that the country is nearly all savanna, either open and grassy or scattered over with bushes and low groves, and that the woods are confined to the hills and to the borders of salt-creeks. . . .

About Cape San Lorenzo (latitude 1° 5' S.) the coast is bold and broken, and almost completely clad with low bushy vegetation. In the village of the same name, which nestles in the bay to southward of the cape, at the mouth of a small stream, the houses stand mixed with Coco palms and Plantains, and steep wooded declivities rise at the back. . . .

A little farther northward, on the river Chones, there is real forest, from which much timber is obtained for Guayaquil.^b

^a For the facts stated in this paragraph I am indebted to Mr. W. E. Safford, of the Bureau of Plant Industry, U. S. Department of Agriculture.

^b Spruce, Richard, *Notes of a Botanist on the Amazon and Andes*, edited by A. R. Wallace, vol. 2, pp. 328, 329. (London, 1908.)

As soon as the coast belt is passed the coconut palms are able to thrive, not only at Guayaquil, but much farther to the southward. The following statement by Spruce shows the existence of coconut palms in an oasis of the desert in the region of Payta, in northern Peru:

When the traveler across the des poblado comes suddenly on one of the valleys, he passes at once from a desert to a garden, whose charms are enhanced by their unexpectedness. Standing on the cliff that overlooks the Chira, about Amotape, he sees at his feet a broad valley filled with perpetual verdure, the great mass of which is composed of the pale green foliage of the Algarroba; but the course of the river that winds through it is marked (even where the river itself is not seen) by lines or groups of tall Coco palms, here and there diversified by the more rigid Date palm, both growing and fruiting in the greatest luxuriance, their ample fronds never mutilated by caterpillars, as they are wont to be in other regions.^a

POSSIBILITIES OF THE COCONUT PALM IN THE UNITED STATES.

It will be apparent from the preceding chapters that we are not to expect the coconut palm to attain its utmost limits of extratropical distribution along the seacoast, but in interior localities that afford larger amounts of heat and sunlight. Applying these considerations to the United States, we ought not to accept as final the present limitation of the coconut palm to extreme southern Florida, but should test the possibility of establishing it in the frost-free interior valleys of southern California and Arizona. The low summer temperatures of the coast belt of California would doubtless exclude the coconut palm, though some of the Brazilian species of *Cocos* appear to thrive in the region of Santa Barbara and also farther north in Florida than the existing varieties of the true coconut.

The fact that the coconut is able to thrive and mature its fruit on tropical seacoasts shows that it does not demand the high temperatures that the date palm requires to ripen its fruit. It seems probable, therefore, that the coconut may prefer districts nearer to the coast in California than the very hot interior valleys where the date succeeds. The region about Riverside, or some of the valleys that are not hot enough for dates, may possibly afford conditions in which coconut palms can thrive.

The possibility of securing useful hybrids between the coconut and other related palms already known to be hardy in California is also worthy of consideration. Some of the Brazilian species of *Cocos* have been reported as thriving in California, as well as the Chilean relative of the coconut, *Jubaea chilensis*, which grows in South America well outside the Tropics.

It is said to extend to 36 degrees south latitude in the wild state, but lives in cultivation still farther south. It has proved hardy in

^a Op. cit., p. 335.

the south of France, where large trees exist more than 30 years old. Twelve degrees of frost have been endured with little or no injury.^a

While experimental plantings of coconuts in frost-free localities in southern California and Arizona are desirable to test the possibility of introducing the coconut into a new region, no assurance can be given in advance that the undertaking will be successful, either to the extent of affording a new agricultural industry or to the lesser extent of introducing a new ornamental palm. The fact that the coconut is not limited to maritime conditions, as usually supposed, but is adapted to dry climates, simply means that previous ideas of the habits of the palm should not be allowed to stand in the way of further study of its possibilities.

The only assurances that can now be given are that the climatic factors do not appear likely to exclude the palm from an extra-tropical distribution in frost-free interior localities with adequate exposure to sunlight, and that the heat requirement is not as great as in the case of the date palm. Whether coconuts can be made to thrive in any locality in the United States outside of Florida can only be determined by experiment. Other factors that are not to be foreseen may interfere with or entirely preclude success. Locusts or other insects or diseases may destroy the palms, as they have done in other parts of the world, or the soil conditions may prove unsuited in some manner that can not be corrected. It is also possible that the palms may not tolerate cold weather, even above the freezing point. Some tropical plants are permanently injured by cold, even when the freezing temperatures are not reached, but this susceptibility is not conspicuous among the palms and is not very likely to appear in the coconut, in view of what we already know of its ability to exist in dry and elevated regions subject to marked changes of temperature.

To undertake the commercial planting of coconuts in California before experiments have shown its feasibility would be altogether unwarranted. Such a caution may appear to some readers as altogether superfluous, but not to those who are familiar with the losses that have come from the premature expansion of rubber culture and other tropical industries in recent years. It is quite possible that coconut palms will be found to grow well in localities where they are able to produce little or no fruit. This would preclude commercial cultivation, but if coconut palms will grow in California, even without producing fruit, their introduction will be abundantly repaid, for they are one of the most beautiful objects in the whole vegetable kingdom and would be "a very great grace" in California as in the "citie of Porto Rico."

^a André, E., *Revue Horticole*, vol. 74, p. 8. (1902.)

An adequate test of the possibilities of the coconut palm in California and Arizona can not be made by planting commercial nuts raised on tropical seacoasts. Except in South America, all the attempts to grow coconut palms in interior localities have probably been made with varieties brought in from neighboring coasts. It is something to know that the maritime varieties are able to grow away from the sea, but it is not at all to be expected that such varieties will represent the best possibilities of the species in subtropical localities away from the seacoast.

To rely upon maritime varieties for an experiment in the United States would be the same as to expect hothouse varieties of grapes or lettuce to excel in tests of hardiness. If an effort is to be made to establish the coconut in California, it should be based upon the study and introduction of the varieties that have shown their ability to thrive in the dry interior valleys and plateaus of South America, and especially the varieties that are able to withstand the most extreme conditions of drought and cold. In tropical countries the climatic conditions often differ greatly, even within very short distances. One valley or mountain slope may have a very prolonged dry season and wide extremes of temperature, while the next may have equable temperatures and relatively continuous humidity. Plants with large, heavy seeds are likely, in their natural state, to be confined to very limited districts, and this is to be expected of the wild stock or the native varieties of the coconut if any have survived in the original home of the species.

It seems strange that the numerous maritime varieties of the coconut which exist in the East Indies have never been introduced and tested in the West Indies or in southern Florida. They may be expected to differ quite as much in hardiness and earliness of bearing as in the characteristics of the nuts. Hardier or earlier coconuts would have a distinct value in southern Florida, since it would permit a more northern extension of the planting of coconuts, which is now confined to the keys and to the southern shores of the peninsula.

Conditions favorable for the coconut palm may also be found in interior localities of Palestine and Upper Egypt. In the coast districts where the summer climate is dominated by cool winds from the Mediterranean the heat requirements would not be met, but the interior valleys afford many sheltered places with tropical temperatures in summer and free from frost in winter. The soil requirements must be considered, of course, as well as the climate, but experiments might be well worth the making.

It is said that coconuts were germinated some years ago a few miles below Cairo, but the garden was abandoned and the young palms allowed to die for lack of water. Though royal palms and

several other species have been found to thrive, Cairo may be still too near the sea to give the most favorable conditions for the coconut. The partial shade of gardens that seem to be well suited to *Cocos plumosa* and other Brazilian species would not favor the true coco palm. Shelter against cold winds may be an advantage, but the young palms will probably require full exposure to the sunlight. The coconut may behave like the doum palm, that thrives in Upper Egypt but is kept alive only with difficulty in the gardens at Cairo.

That the possibility of growing coconuts in Egypt and Palestine should not have been more thoroughly tested may seem very strange, but it should be remembered that the Mediterranean region had no direct communication with coconut-producing tropical countries before the opening of the Suez Canal. Though the Poinciana, the banyan (*Ficus bengalensis*), the Assam rubber (*Ficus elastica*), and many other tropical trees have been established as ornamentals about Cairo and other towns, many other tropical and subtropical species that are likely to prove well adapted to the conditions remain to be introduced. Now that selected fresh nuts can be brought by swift steamers from Ceylon or other parts of the East Indies, other experimental plantings of coconut palms will doubtless be made.

SUMMARY OF RESULTS.

The history of the coconut palm has relation to several different kinds of scientific questions, so that the facts require to be summarized from several different standpoints.

BOTANICAL CONCLUSIONS.

All the palms that are related to the coconut, comprising about 20 genera and 200 species, are natives of America, with the possible exception of a single species, the West African oil palm. All the species of the genus *Cocos* and of the closely allied genera are natives of South America. The species of *Cocos* that are most related to the coconut are natives of the interior valleys and plateaus of the Andes, where the coconut also thrives, remote from the sea.

Comparison of the structure of the fruit and the method of germination of the coconut with those of the related palms indicates a high degree of specialization, but not for purposes of maritime distribution. The unusually large, heavy seed and the thick, fibrous husk are to be considered as adaptations for protecting the embryo, assisting in germination, and establishing the young plants in the dry climates of interior localities, the only conditions where this palm could be expected to maintain its existence in a wild state.

The habits of the coconut palm afford no indication that its original habitat was on the seacoast, and none of its closer relatives have maritime habits or maritime distribution. The coconut palm

does not appear to be able to maintain itself under littoral conditions without the assistance of man. Though carried by man to all of the warmer parts of the earth, it has not been able to establish itself as a wild plant on any tropical coast, but is always crowded out by other vegetation after human care is withdrawn.

Wafer's circumstantial account of the existence of large numbers of coconut palms on the Cocos Islands, 300 miles west of Panama, in 1685, taken together with their almost complete disappearance at the present day, affords a striking illustration of the dependence of the coconut upon human assistance not only for its distribution, but for its continued existence on oceanic islands.

The dissemination of the coco palm along the tropical coasts is to be ascribed to the agency of primitive man, as with the sweet potato, banana, and other domesticated plants which were widely distributed in prehistoric times. The theory that it has been disseminated by ocean currents is gratuitous, unproved, and improbable.

The development of distinct varieties of the coconut has not been confined to the Polynesian and Malayan islands. Distinct varieties are also to be found in isolated localities in America, such as the Soconusco region of Mexico and the island of Porto Rico.

The existence of many and diverse varieties in the Malay region does not indicate that the species is native there, but the opposite, since the proximity of the wild stock of a species is likely to hinder the appearance and preservation of mutations among its cultivated representatives. The relative uniformity of the coconuts of America is in accord with the probability of an origin in this hemisphere. The discovery of distinct varieties in isolated localities in America accords with the probability that the Malayan varieties have arisen, like other cultivated varieties, through segregation and mutation rather than by gradual evolution and natural selection.

HISTORICAL CONCLUSIONS.

At the time of the discovery of America the coconut was not confined to the Pacific side of the Isthmus of Panama, as De Candolle believed, but was already widely distributed along the Atlantic side of the American tropics. Early records show its presence in Cuba, Porto Rico, Brazil, and Colombia at dates so early as to preclude the idea of introduction by the Spaniards.

The statement of Pickering, frequently quoted in works of reference, to the effect that coconuts were reported by Columbus on the coast of Central America during his fourth voyage, proves to be erroneous. On the other hand, there appears to be a definite reference to the coconut in Cuba in the journal of the first voyage of Columbus.

De Candolle's inference from Acosta's report of coconuts in Porto Rico at the end of the sixteenth century, that they had recently been introduced by the Spaniards, proves to have no warrant in history and is directly opposed by the more extended reference to the coconut in Porto Rico by the Duke of Cumberland's chaplain, who visited the island only a few years after Acosta.

De Candolle's use of the testimony of Piso and Marcgrave to support the idea of the introduction of the coconut into Brazil by Europeans is also unwarranted, since those writers only indicated that the plant was cultivated. An earlier and more explicit record, unknown to De Candolle, gives an account of the coconut as one of the native products of Brazil.

The journal of Cieza de Leon, who accompanied the first Spanish expedition to the interior of Colombia, indicates the presence of the coconut palm in localities where it still continues to exist, as shown by the accounts of Velasco, Humboldt, and more recent travelers, down to the present decade.

ETHNOLOGICAL CONCLUSIONS.

The American origin of the coconut palm and the strict limitation of its status in maritime tropics to that of a cultivated plant are facts of ethnological significance. The wide distribution of the coconut in prehistoric times is evidence of the antiquity of agriculture in America and of very early communication across the Pacific.

The American origin of the coconut palm, along with its inability to maintain itself on tropical seacoasts without human assistance, compels us to believe that its trans-Pacific distribution was the work of primitive man. The dependency of the Pacific islanders upon the coconut may be taken to show that these islands could not have been occupied without the previous domestication and dissemination of the coconut.

In view of the fact that several other palms of unquestioned American origin have been domesticated by aborigines of the American tropics, no ethnological objection can be raised to the idea that the coconut palm was originally domesticated in ancient America.

The name "coco" does not appear to have been applied to the 'Indian nut' till after the discovery of America and is to be considered as a word derived from the natives of the West Indies. Other native names for the coconut are found among primitive tribes of Costa Rica, as well as in Brazil.

The presence of large numbers of coconuts on Cocos Island in the time of Wafer (1685) and their subsequent disappearance should be considered as evidence that the island was formerly inhabited, or

at least regularly visited, by the maritime natives of the adjacent mainland.

The fact that the coconut is largely restricted to islands and tropical countries of low elevation explains its importance among the pre-eminently maritime people of the Old World tropics and its relatively slight importance among the nonmaritime natives of the lowland tropics of America.

The evidence of the prehistoric dissemination of the coconut and other American cultivated plants across the Pacific Ocean is such as to warrant a careful consideration of other indications that agricultural civilization developed originally in America and was distributed to the shores of the Pacific and Indian oceans by a primitive people with agricultural and maritime habits, like those of the Polynesians and Malays.

The existence of a distinct tribe of frizzle-haired people near the Isthmus of Panama at the time of the discovery does not rest alone on Peter Martyr's casual mention of the finding of negroes, but is supported by Oviedo's contemporary history written directly from the testimony of Balboa and other members of his expedition, just after their return to Darien. The facts are not to be explained reasonably by assuming a chance arrival of African negroes, but indicate that prehistoric communication across the Pacific continued after the frizzle-haired Melanesian race had spread eastward in the Pacific.

Such communication would account for the existence of the banana plant in America previous to the arrival of the Spaniards, as well as for the Old World distribution of the coconut palm and other cultivated plants of American origin. The banana plant is as evidently a native of the eastern continent as the coconut palm of the western. Evidence of these facts appears very definite and concrete from the biological standpoint, and is worthy of careful consideration by ethnologists.

AGRICULTURAL CONCLUSIONS.

The coconut is confined to seacoasts only in the humid lowlands of the Tropics; in dry regions it is not restricted to coasts, but thrives in many districts remote from the sea. The fact that it received scientific study only as a maritime plant should not longer obscure the fact that it is also adapted to interior localities with saline soils. The cultural problems of the coconut palm should be investigated quite apart from the idea of maritime habits and distribution.

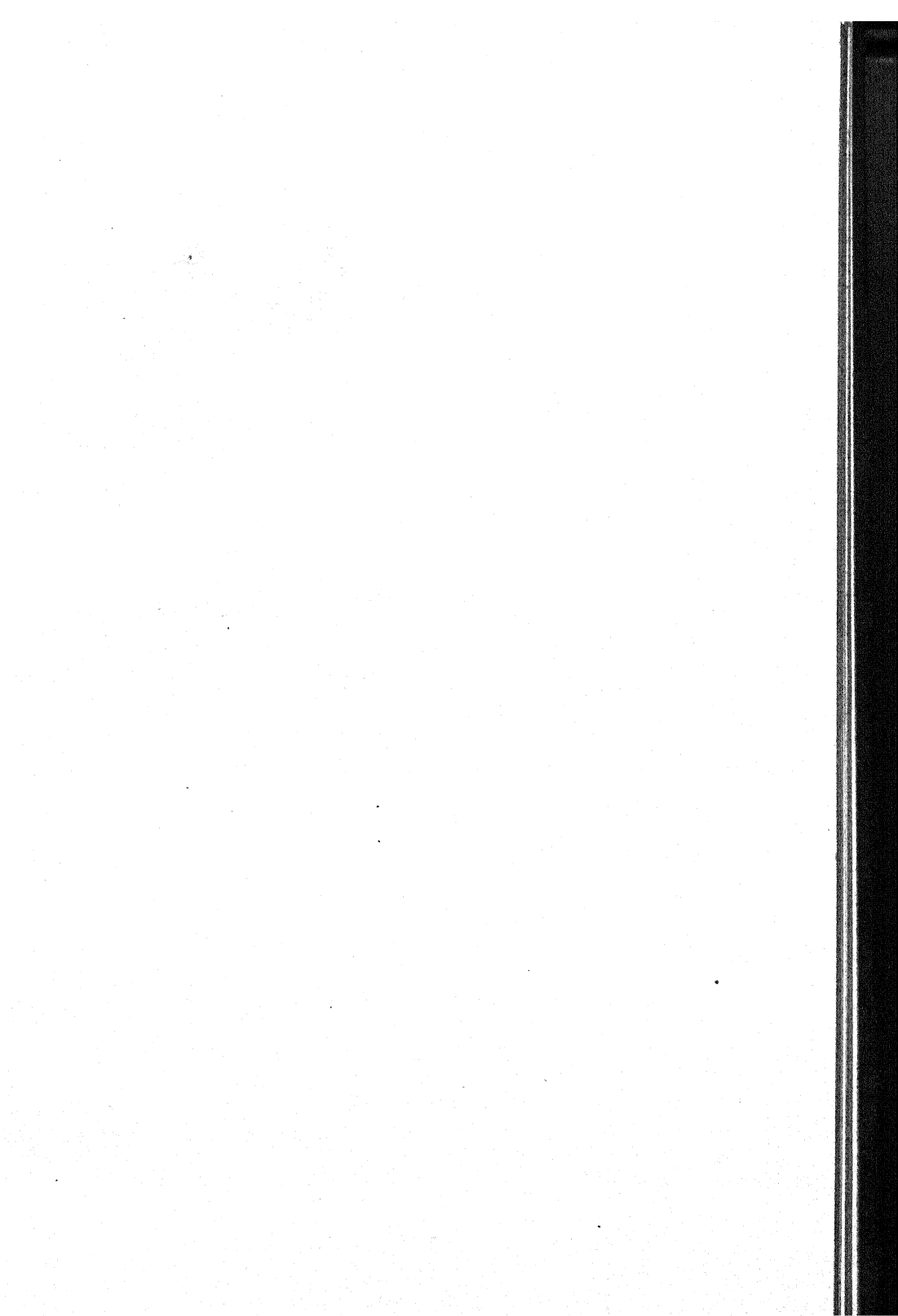
The possibility of raising coconuts in frost-free localities outside the Tropics is not to be tested along the seacoast, but in interior districts where larger amounts of sunlight and heat are available, as in the valleys of southern California and Arizona. The coconut, like

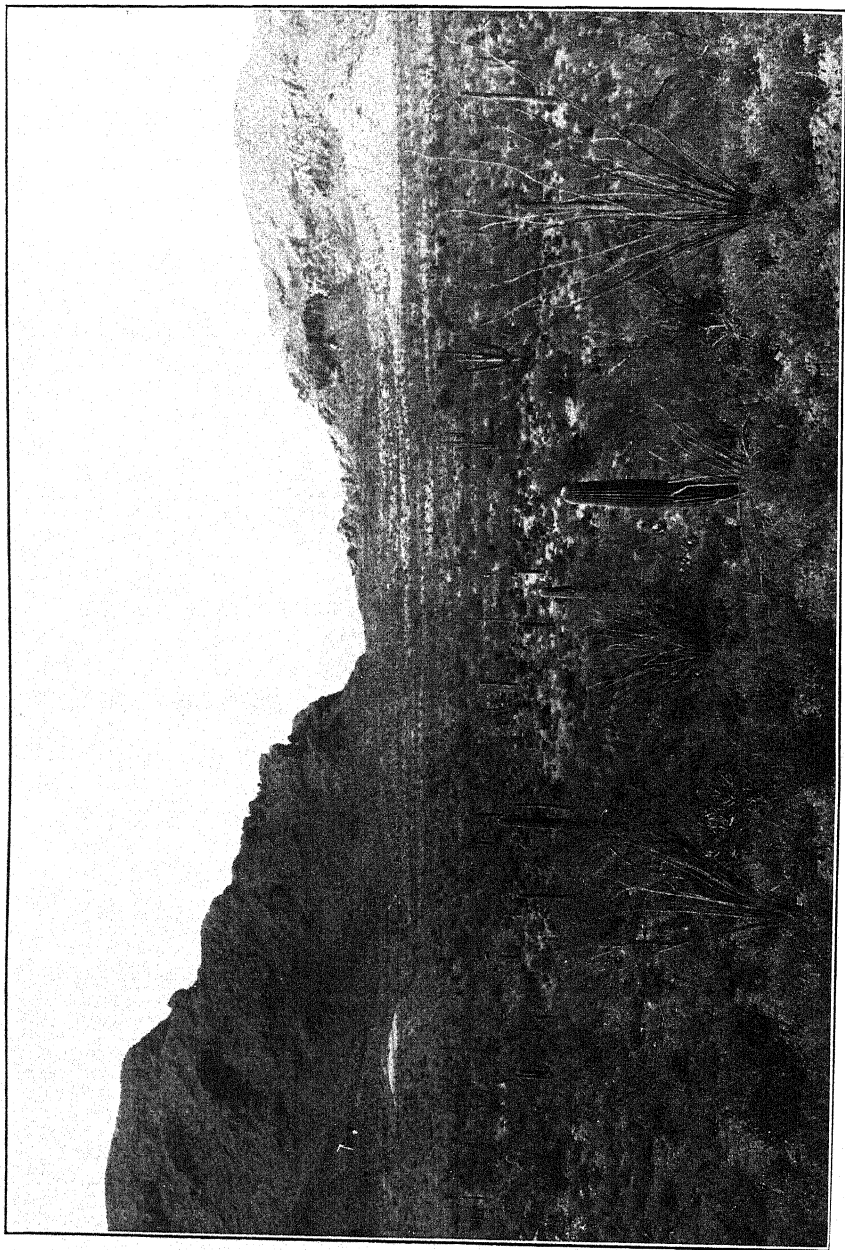
many other palms, is not tolerant of shade nor of long continued cool and cloudy weather. Other species of *Cocos* that are less exacting in their requirements of sunlight and heat have been found to do well along the California coast.

The possibility of introducing coconut palms into southern California is not disproved by the absence of these palms from Egypt and Palestine. Though the climatic conditions are probably favorable, it does not appear that any adequate effort has been made to introduce the palms in those countries.

The ability of the coconut to thrive on seacoasts shows that its requirements of heat are not as great as those of the date palm. Though probably less hardy than the date palm, it is not impossible that the coconut may be able to exist in frost-free localities that have not enough heat for the ripening of dates.

The possibility of introducing the coconut palm into southern California and Arizona can not be fairly tested by the planting of the maritime varieties. The chances of success will be very much greater with the varieties that are adapted to the dry interior localities of the temperate plateaus of the Andes.





HABITAT OF *BOUTELOUA* SPP. IN THE TUCSON MOUNTAINS, ARIZONA.

Arid low mountain situations occupied by forms of the low-growing species, *B. aridoides* and *B. barbata*. The main shrubbery consists of *Cercus* *giganticus*, *Bouquertia splendens*, *Acacia constricta*, *Prosopis juliflora*, and *Franseria*.

THE GRAMA GRASSES: BOUTELOUA AND RELATED GENERA.

By DAVID GRIFFITHS.

INTRODUCTION.

BASIS AND METHODS OF THE WORK.

It was during the writer's connection with the University of Arizona in 1900 that work was begun on this group of plants. Preparations were then made to grow the plants under cultivation at the University in a region where the species predominate in the grass flora and form the main feed upon public and private stock ranges. A change of location caused a change of the plan of work. Since 1901 the writer's studies in the field have been carried on during extensive travel on behalf of the Department of Agriculture for the study of the public stock ranges and other purposes. In addition, travel has been performed extensively in Mexico under conditions which have allowed good opportunity for study.

The material in the following herbaria has been examined: United States National Herbarium, Gray Herbarium, herbarium of the Missouri Botanical Garden, herbarium of the Field Museum of Natural History, herbarium of the California Academy of Sciences (before the fire), and the private herbaria of Brandegee and Tracy. But while the collections in these herbaria were studied, the work is based mainly upon the material in the United States National Herbarium, and the specimens listed are almost entirely from that repository.

During his visit to Europe in 1907, Prof. A. S. Hitchcock secured, through the kindness of the directors of the herbaria there, fragments of several typical or authentic specimens for deposit in the National Herbarium. In other cases he procured photographs of type specimens and made notes and drawings that have greatly aided in the interpretation of the older names of the species. Further information has been obtained through correspondence with the directors of the botanical gardens at Kew and Berlin, to whom acknowledgments are due for their courtesies.

The drawings accompanying this paper were prepared by Mrs. Agnes Chase, to whom the writer is indebted for numerous notes upon the minute structural details of the species. The half tones, except plate 69, are from photographs taken by himself, and now the property of the United States Department of Agriculture.

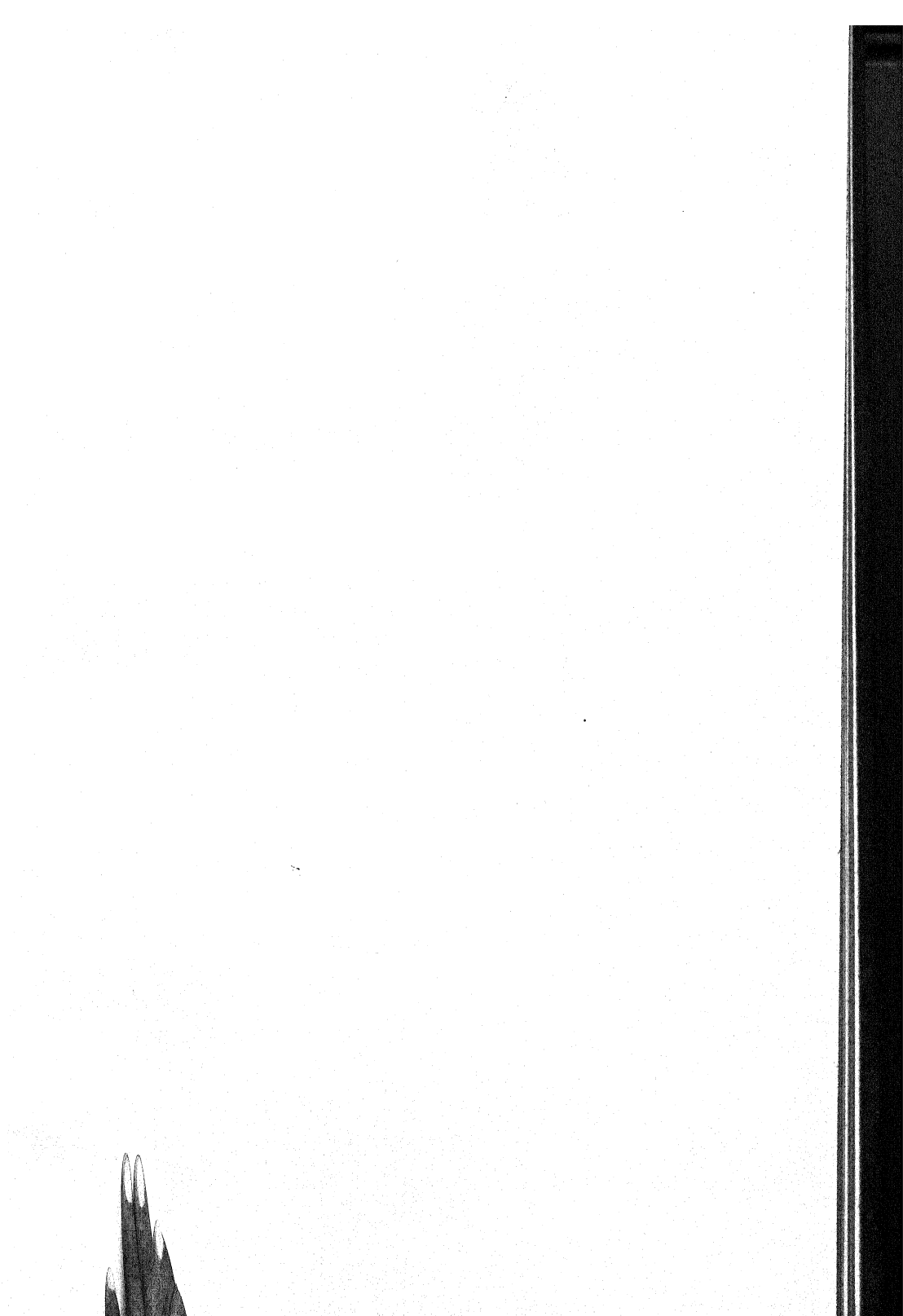
ECONOMIC IMPORTANCE OF THE GRAMA GRASSES.

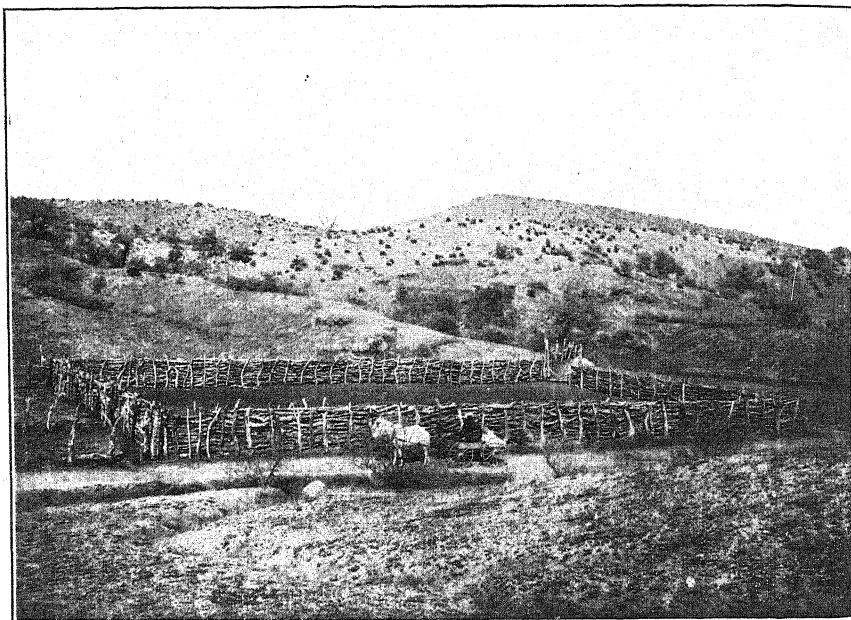
It is doubtful whether there is another group of native pasture grasses which is of as much economic importance as this, when both quality and quantity are considered. In the northern prairie region *Bouteloua gracilis* forms a very large part of the so-called "buffalo-grass formations," and makes a very fair sod over thousands of square miles. The arable lands upon which this species forms a good turf, however, are rapidly being broken up and devoted to ordinary farm crops, so that in the north the areas of grama have been very much reduced in the last 20 years.

In the arid Southwest, where the species are not turf formers, except at an altitude of 5,000 to 7,000 feet, the grama grasses are nevertheless of great importance, including, as they do, species which not only inhabit this region, but which actually furnish the greater part of the feed at altitudes from 7,000 feet down to the driest desert mesas and lowlands. It is a noteworthy fact that the species which produce not only the greatest amount of feed, but the best feed as well, occupy the higher levels. This is of course accounted for by the heavier precipitation.

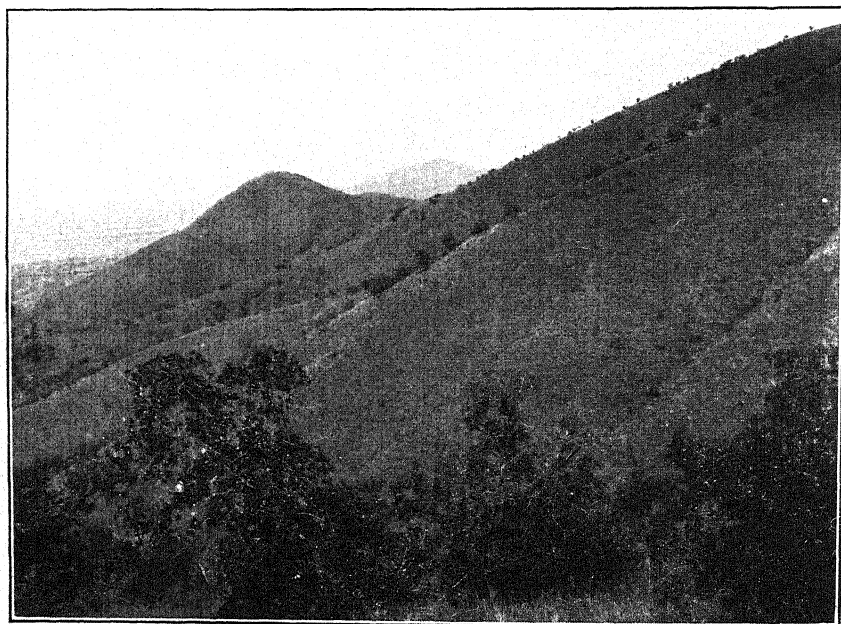
The conditions upon the highland of Mexico are very much the same as in the southwestern part of the United States, the high tablelands being imperfectly sodded with *Bouteloua gracilis*, *B. chondrosioides*, *B. filiformis*, *B. radicata*, *B. hirsuta*, etc., and the lower levels producing varying growths of such species as *B. barbata* and *B. aristoides*. The first group especially includes the main pasture grasses over very large areas.

The species are preeminently pasture grasses and have been so recognized since they were first studied. Lagasca called attention to them in a very positive fashion as early as 1805, and our early explorers were unstinting in their praises of the gramas. It not infrequently occurs, however, that many of the species enter quite largely into the composition of hay. Upon the prairies of the North Central States *B. gracilis*, formerly to a much greater extent than at present, was extensively cut with *Agropyron smithii*, Koeleria, and other prairie species. Farther south, in Nebraska, Kansas, Oklahoma, and northeastern New Mexico, *B. curtipendula* is more conspicuous, and *B. hirsuta* is also of some importance mixed with various species of *Andropogon* on sandy-loam soils. The most valuable species, however, aside from *B. curtipendula*, do not well adapt themselves to

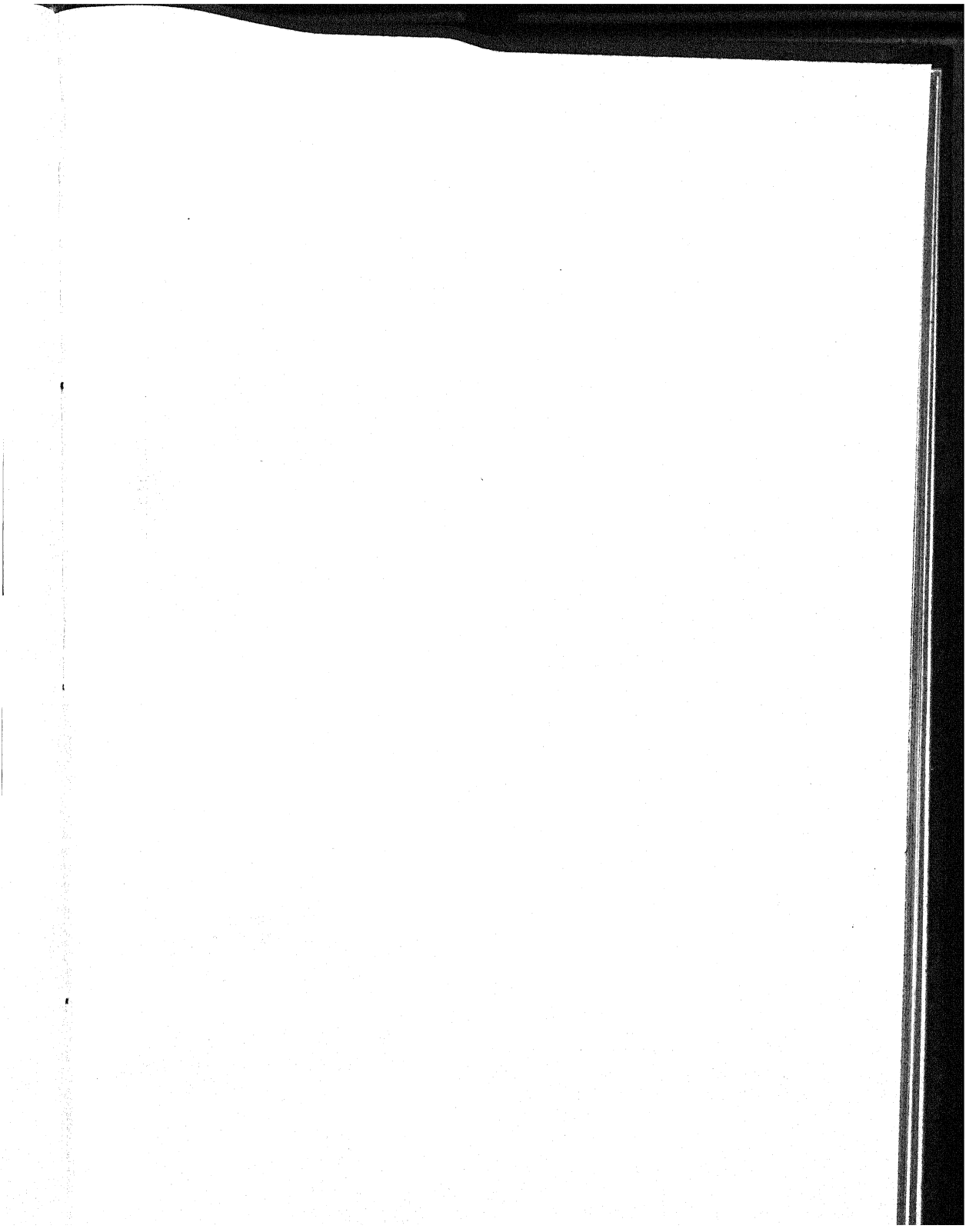




A. CLOSELY GRAZED BOUTELOUA REGION IN SOUTHERN ARIZONA.

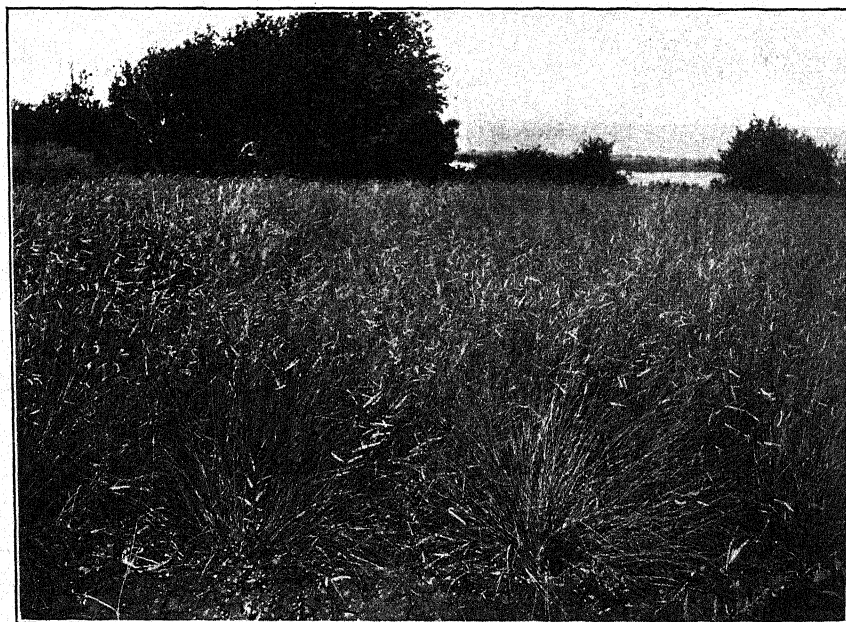


B. HABITAT OF TALL-GROWING SPECIES OF BOUTELOUA IN SOUTHERN ARIZONA.





A. *BOUTELOUA CURTIPENDULA* (MICHX.) TORR. IN CULTIVATION.



B. *BOUTELOUA GRACILIS* (H. B. K.) LAG. IN CULTIVATION.

cutting for hay. In the main the nutritious and valuable herbage of the grama grasses consists of their basal leaves, and these grasses are consequently adapted mainly to grazing.

In the main the perennial species very well withstand heavy grazing and the abuses incident to the open range method of handling stock. Indeed, there are few if any grasses that are superior to them in this regard. *Bouteloua gracilis* is the species of prime importance in the prairie region, and, together with *B. chondrosioides*, *B. filiformis*, *B. radicata*, etc., is also important upon the higher lands farther south. No recorded experiences upon the behavior of these plants under cropping systems in the Southwest are known except the general observation that too close grazing reduces the vitality of the plants, and, if long continued, kills them out entirely (Pl. 68, A). Upon the northern prairies many observations have been made upon the behavior of the prairie grasses when cut for hay. The extent and degree of cropping have been much more definitely observed in the prairie region. In the Dakotas, *Bouteloua gracilis* withstands grazing very well, but if grazed closely for even one season it takes it two or three years to recover. It is the common experience that hay can not be cut on the upland prairies oftener than once every two years. In other words, the removal of the ground cover of one year's growth, as close as the mower takes it, sets the plant back at least one year, while burning is still more detrimental. But this applies to the prairie grasses in general.

ADAPTABILITY TO CULTIVATION.

Many efforts have been made to cultivate the different species of *Bouteloua*, especially during the grass-garden period of experimentation in this country, from about 1892 to 1900.

The most promising of all the species for field cultivation is *B. curtipendula* (Pl. 69, A), not that it grows any more readily than the others, but on account of its size and habit. All the species respond readily to cultural treatment, but none of them have a good seed habit, a very important characteristic in an agricultural grass. The seed can not easily be even properly thrashed. All that can be done is to strip off the spikes, which separate readily from the panicle upon maturity. The whole spike has been invariably sown. In *B. gracilis* and allied forms the spikelets readily separate from the spikes, but even here it would be impracticable to attempt to secure clean seed.

EXPLANATION OF PLATE 68.—A. A region in which about half a dozen species of *Bouteloua* grow in profusion whenever summer rains are seasonable, in spite of the fact that it is continuously closely grazed. B. Scene in the Santa Rita Mountains, Arizona. *Bouteloua curtipendula* and tall forms of *B. hirsuta* and *B. radicata* predominate, mixed with species of *Leptochloa*, *Andropogon*, *Heteropogon*, *Muhlenbergia* and *Panicum*.

EXPLANATION OF PLATE 69.—A. *Bouteloua curtipendula*. B. *Bouteloua gracilis*. Both growing at Walla Walla, Washington. Photographs by Leckenby.

The spikes of many of the species also drop off very readily when they approach maturity, and it is thus difficult to save the seed. So pronounced is this tendency in some species that it is impossible to prepare good herbarium specimens of plants in the mature state. This accounts for some of the taxonomic errors that have crept into our conceptions of the species. Collectors have commonly selected plants which could be made into good herbarium specimens, or, having collected mature ones, the spikes have been lost.

Bouteloua gracilis (Pl. 69, B) makes a splendid turf when sown thickly and well cared for. In some places upon the native prairies and foothills of the Northwest beautiful natural turfs of this and *Bulbilis* are common. Although the quality of the turf is good it has the disadvantage of being green but for a short season.

In short, it is more than probable that, because of the lack of good seed habits in this genus, even the most valuable species can not become of importance in cultivation, although good yields of hay can be secured from *B. curtipendula* at least (Pl. 69, A), and good stands can be secured with any of the other perennial valuable species if the seed be secured and sown thick enough.

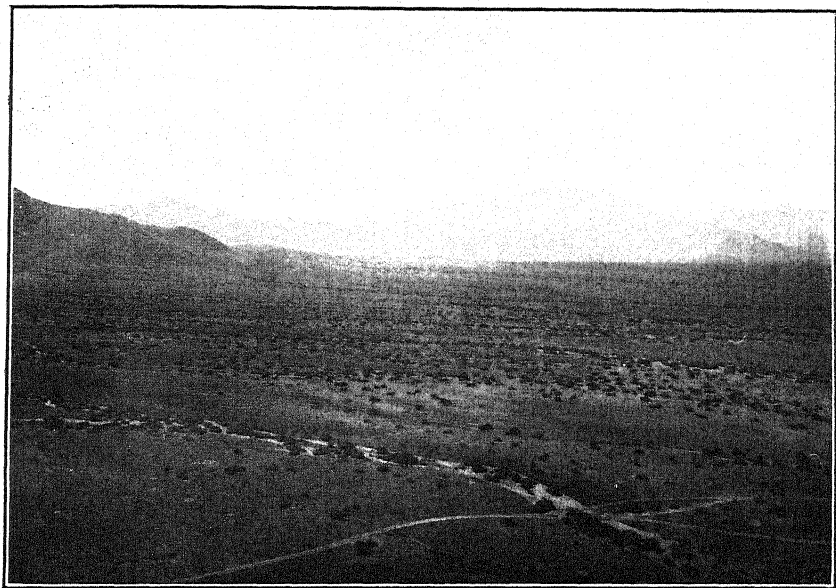
DISTRIBUTION.

It is exceedingly difficult to give any definite and concise information regarding the altitudinal distribution of the species. *Bouteloua gracilis* is at home upon the prairies at an altitude of 1,000 feet, and, as we have seen, the same form occurs at 7,000 feet or more in the San Francisco highland of Arizona, and at much lower levels in the Santa Rita Mountains, while the taller form grows as low as 4,000 feet in the Santa Rita Mountains of Arizona. Precipitation is a much more important factor than altitude. So far as temperatures are concerned, *B. gracilis* endures -40° F. in the northern plains and makes a good growth in nearly frostless regions upon the highlands of central Mexico, while it sometimes endures a maximum of 100° F. in the summer season.

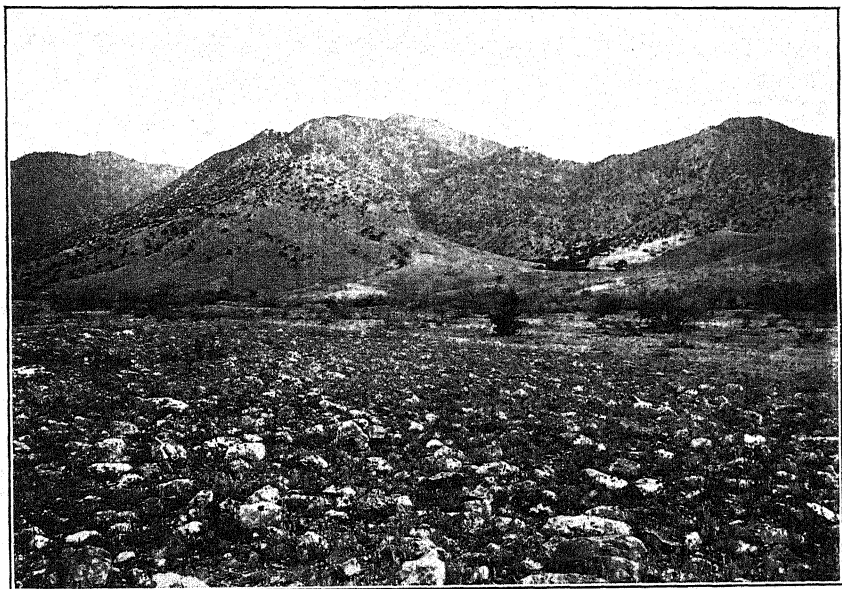
In a circumscribed *Bouteloua* area there is quite a well-marked zonal distribution of some of the species (Pls. 68, B; 70, A, B; 71, A, B). As an example may be mentioned the region north of

EXPLANATION OF PLATE 70.—A. Scene from north of the Santa Rita Mountains in southern Arizona. In the foreground *B. aristoides* predominates and *B. parryi* is common. A little farther out *B. rothrockii* and *B. filiformis* are the prevailing species. On the lower portion of the steep slopes *B. curtipendula* and *B. hirsuta* are very abundant, the former reaching an altitude of 5,000 feet, about the highest points at the left of the picture. About one-third way up the sides of the mountains to the right *B. radicata* is abundant, while on southern exposures at the altitude of the small cone in center of picture *B. eludens* occurs sparingly. B. A portion of the same area close to the mountains to the right, as seen in the spring of the year. Compare these with plate 75, B. It will be seen that the crop of grass, mainly *Bouteloua*, is all eaten off and there is now a crop of annual weedy plants consisting mainly of *Plantago*, *Pectocarya*, *Eschscholtzia* and a few small annual composites.

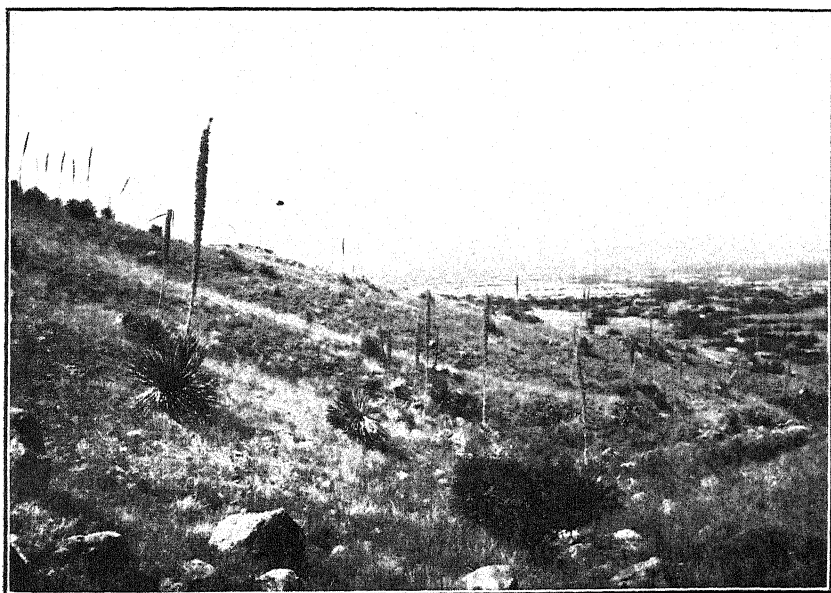
EXPLANATION OF PLATE 71.—A. A closer view of ground shown in the left-hand part of plate 70, A, showing summer condition of region similar to that shown in plate 70, B. The graminas in the foreground are mainly *B. curtipendula*, *B. hirsuta*, *B. filiformis*, and *B. eriopoda*. *Dasylirion wheeleri* also shows prominently. B. Scene in the Altar Valley, Arizona, Baboquivari Peak in the background. In the foreground are shown *B. rothrockii*, *B. barbata*, *B. aristoides*, and *B. filiformis*.



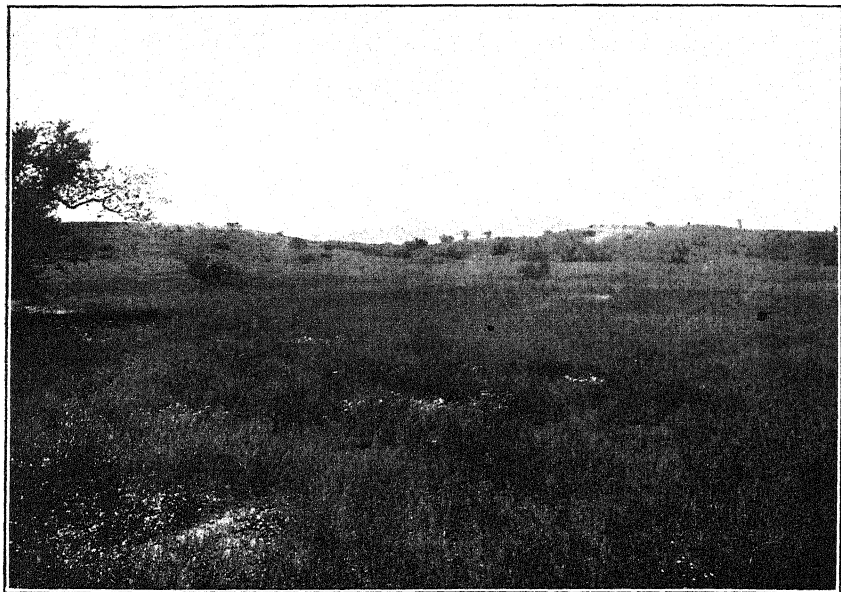
A. GENERAL VIEW OF A GOOD BOUTELOUA REGION.



B. SPRING VIEW OF A BOUTELOUA REGION CLOSELY GRAZED.



A. TYPICAL VIEW IN A BOUTELOUA REGION, SHOWING A VARIETY OF SPECIES.



B. BOUTELOUA REGION WITH A DIFFERENT SOIL AND DIFFERENT SPECIES.

the highest point of the Santa Rita Mountains of Arizona. From the 4,500 to the 5,000 feet level on the north side of this mountain *B. radicata* is abundant. From about 4,500 feet down to 3,800 feet *B. filiformis* is commonly the prevailing species. From 3,800 to 3,400 feet *B. rothrockii* is often the most important plant, and it goes here as low as or lower than any of the other perennial species. Throughout this entire range, from 4,500 to about 3,500 feet, *B. curtipendula* may be found, but usually only upon the rougher lands, and it increases in importance upward, becoming the most important species upon the rocky upper foothills at 4,000 feet. *Bouteloua aristoides*, on the other hand, is of wide distribution and may be found from the upper Bouteloua limit to the lower mesas (Pl. 67, facing p. 343), and even across them clear to the lower Colorado and into the Salton Sink below the level of the sea. Its greatest development is in the lower part of the perennial grass region, about the 3,500 feet level. It is found, in occasional years only, where there is a temporary accumulation of flood water, also in favorable places in the mesas, where the regular annual accumulation commonly produces perennial species of *Hilaria*. In this general Bouteloua belt, mostly at about 4,000 feet, may be found scattering patches of *B. parryi*, *B. cludens*, and *B. eriopoda*, and, especially below, *B. barbata* is frequently met with.

Roughly speaking, the great Bouteloua region of the world extends from Saskatchewan and Manitoba southward between the Mississippi River and the Continental Divide. The western border crosses the Divide in Wyoming, extends into the southern Great Basin region, and strikes the Pacific coast at about the Mexican boundary. In Mexico the grama grasses extend from coast to coast, reaching their greatest development upon the highland, and disappearing entirely in tropical situations of uniform heavy humidity. They are especially abundant and important in those elevated regions which have a heavy summer precipitation and are comparatively dry the rest of the year. *Bouteloua curtipendula* is common in the eastern United States and *B. hirsuta* is prominent in portions of Florida.

The writer's knowledge of South American species is based entirely upon a study of meager collections which do not warrant any conclusion other than that the species appear to be more or less common in the Cordillera region. A few species are of frequent occurrence in portions of the West Indies and other continental islands.

ILLUSTRATIVE MATERIAL.

Field studies have brought together sufficient material in the group to warrant the distribution of a set of specimens illustrating the writer's conception of the species. These sets, so far as material is available, are deposited in the leading accessible consulting herbaria.

A total of nine sets have been put up and deposited as follows:

United States National Herbarium, Washington, D. C.

Gray Herbarium, Cambridge, Mass.

New York Botanical Garden, New York City.

Missouri Botanical Garden, St. Louis, Mo.

Field Museum of Natural History, Chicago, Ill.

University of California, Berkeley, Cal.

Royal Botanic Gardens, Kew, England.

Königlicher Botanischer Garten, Dahlem-Steglitz bei Berlin, Germany.

Muséum d'Histoire Naturelle, Paris, France.

Beginning on page 425 will be found a list of the species which are being thus distributed, together with designation of the sources of the material. The types of the new species here proposed are contained in the set deposited in the United States National Herbarium at Washington. In some cases the numbers are distributed under other names than those of the text because they were arranged before the work on the text was completed.

LIMITATION OF THE GENERA.

The genus *Bouteloua*^a was established by Mariano Lagasca in *Variedades de Ciencias, Literatura y Artes* (Madrid) in 1805. So far as I am able to determine he has expressed in no way what species he considers typical of the genus, although an elaborate discussion is given of the characters and of the economic importance of the group as pasture grasses. Apparently the only way of fixing the type of the genus is to choose the first species listed. This method is as usual the most easily applied in fixing the generic type, and under the application of this rule the name *Bouteloua* will have to stand for the genus, however that genus is limited, containing the first species, *Bouteloua racemosa* Lag., which is clearly the same species as the earlier described *Chloris curtispindula* Michx. Lagasca wrote another and more comprehensive treatise upon the same genus eleven years later, in which *B. hirsuta* is the first species listed and *B. racemosa* the last. In this treatise Lagasca again fails to indicate what he considers the type of his genus. However, the application to the 1805 paper of this arbitrary principle of priority of place is not here considered to be at all affected by the subsequent publication.

^aOriginally this was written *Botelua*, although Lagasca states that it is dedicated to two Spanish gardeners, brothers, of the name of Boutelou. In a later paper (*Gen. & Sp. Nov.* 1816) he adopts the spelling used here.

This is not the method followed in some of the recent literature of the grasses, and it is in no closer accord with recent practice than is the comprehension in one genus of all the species here included. Kunth^a was the first excessively to divide the group, and to some extent his work has been adopted by some recent authors. Others have contented themselves with adopting Kunth's genera as subgenera or sections. Were I to divide the genus, however, the lines laid down by Kunth would have to be somewhat modified as has been done by Nash.^b Kunth includes in *Dinebra* *Bouteloua curtipendula* and *B. aristidoides* as well as *B. radicata*, *B. repens*, and *B. chondrosioides*, while for *Aristida americana* of Linnæus, the West Indian representative of our *B. filiformis*, which is a variant very close indeed to that species, the monotypic genus *Heterostega* of Desvaux was adopted. The other monotypic genus, *Polyodon* H. B. K., should also, without doubt, be included with the *radicata-repens* section of the genus to which Kunth applied the name *Dinebra* Jacq. *Chondrosium* on the contrary is better delimited and could stand on its merits without change better than the others.

Although Kunth formally recognized all these genera it was against his best judgment that this was done. He specifically states that in his opinion these genera should be united. The disposition made here was decided upon before the opinion of Kunth was discovered. His opinion^c corresponds very closely indeed with my own preference.

There has been much difference of opinion as to the relationship of *Cathetecum* ever since it was established by Presl.^d By Bentham and Hooker it was placed in the *Zoysieae* along with *Aegopogon*, which closely resembles some species of *Bouteloua* and probably should stand closer to that genus than it is now placed. By Hackel *Cathetecum* is included in the *Festuceae*. But the species of this genus in general aspect as well as in minuter details very closely resemble some species of *Bouteloua*. The resemblance in the field is so great that botanists usually refer their collections of *Cathetecum* to *Bouteloua*.

The group differs from the remainder of the grama grasses in having 3 spikelets in the spike, in the reduction of the first glume in one or all of the spikelets, and in a tendency to multiplication of awns by division of the nerves of the lemma of the upper florets.

^aH. B. K. Nov. Gen. & Sp. 1: 171-176. 1816.

^bSmall, Fl. Southeast. U. S. 137. 1903.

^cH. B. K. Nov. Gen. & Sp. 1: 173. 1816. The last paragraph on the page reads as follows: "Heterostega vix genus distinctum, habitus Dinebrae, characteres Chondrosii; genera Heterostegae, Chondrosii et Polyodontis, ut mea fert opinio, valde artificialia, et aptius generi Dinebrae conjungenda sunt."

^dRel. Haenk. 1: 295. pl. 42. 1830.

Pentarrhaphis, established by Kunth,^a was based upon *P. scabra*, which remained practically unknown until Hackel and Scribner identified it and added another species in 1890.^b Since the addition of this second species it is best separated from the other genera by its spikes of 2 spikelets, one of which is aborted in *P. scabra*. There appears to be no other character upon which it can be segregated.

The monotypic genus *Triaena*^c is separated by its spikes of a single spikelet. With it will naturally fall *Bouteloua uniflora* when this character alone is considered, but the latter species is manifestly very closely related to *B. curtispindula*. Indeed, it is quite probable that further collections may prove that the former is simply an unusual form of the latter.

BIBLIOGRAPHICAL NOTES.

There has always been a question regarding some of Lagasca's names. Kunth's figures,^d however, are recognizable by one who is familiar with the species. The examination of a large number of authentic specimens has elucidated many obscure names, but there are a few more that, unless more evidence can be found, will always remain doubtful species.

Cervantes's ^e names published under the genus *Erucaria* have been rejected almost *in toto*. It would be very desirable to refer these names properly, although it is not probable that they would seriously affect the synonymy.

The next most difficult work to interpret is that of Fournier.^f Fragments of specimens cited from European herbaria have assisted greatly in settling doubtful questions. The examination of a cited number, however, is not sufficient to identify Fournier's species, for different species are found at times under the same number in different

^a In H. B. K. Nov. Gen. & Sp. 1: 178. pl. 60. 1816.

^b Bull. Torrey Club 17: 233. pl. 108. 1890.

^c H. B. K. Nov. Gen. & Sp. 1: 178. 1816.

^d H. B. K. Nov. Gen. & Sp. 1: pl. 51-60. 1816.

^e La Naturaleza 1: 347. 1870.

^f Mex. Pl. 2: 1881. There is a difference of opinion about the proper date to cite for this work. It seems desirable to bring together here the available facts which appear to be as follows:

1. Fournier read a paper before the Academy of Sciences of Paris, June 10, 1878, in which he stated that this work was completed and in which he gave data regarding the distribution and number of species. (Compt. Rend. Acad. Sci. (Paris) 86: 1441. 1878.)

2. Bentham received in 1881 a copy marked "proof sheets" (see Hitchcock and Chase, Contr. Nat. Herb. 15: 49. 1910) with neither index nor title page. (Journ. Linn. Soc. Bot. 19: 14-134. 1881.)

3. Hackel also received a copy of the work excluding title page and terminating with page 144 (18 sheets) in 1881.

herbaria. The specimens in the herbarium of the Museum of Paris must be taken as the basis of his work, but some of the numbers cited have not been found there and a few have not yet been found elsewhere.

DESCRIPTION OF THE GENERA AND SPECIES.

THE BOUTELOUAE.

Plants annual or perennial, caespitose or stoloniferous, with spikes one to many, mostly several to many, arranged in unilateral racemes, the spikelets mostly nearly sessile in two rows on a flattened rachis which may be simple or forked distally, but so twisted upon their very short peduncles as to appear more or less unilateral especially when young; spikelets mostly 2-flowered, one of the florets rudimentary, in some cases an additional 1 to 3 rudiments; lemmas 3-nerved, 3-awned, with a 2-nerved mostly shorter-awned palea.

KEY TO THE GENERA AND SPECIES.

Spikes consisting of less than 3 spikelets (except in *B. uniflora*).

Spikes consisting of 1 spikelet; rudimentary spikelet
trifid. (TRIAENA, p. 354.)

Spikes consisting of 2 spikelets, both perfect or 1 rudimentary. (PENTARRHAPHIS, p. 355.)

One spikelet rudimentary, represented by 2 setae
only..... 1. *P. scabra*.

Both spikelets fully developed..... 2. *P. polymorpha*.

Spikes consisting of 3 or more spikelets.

Spikes consisting of 3 spikelets. (CATHESTECUM, p. 358.)

Plants annual..... 1. *C. prostratum*.

4. Bentham states (loc. cit.) that he is bound to treat it as having taken date, and Hackel used it in the preparation of his part of the grasses in Martius's Flora of Brazil, published July 1, 1883. (Bot. Centralb. 28: 232. 1886.)

5. Hemsley (Biol. Centr. Amer. Bot. 3: November, 1885) cites it freely and to the end of the grass volume from the Bentham copy.

6. The copies of Bentham and of Hackel were not galleys nor even page proofs in the ordinary sense, but the signatures in sheets as they came from the press. In other words, the work had taken form and was printed in 1881.

7. Hackel did not receive the index until 1886, although he applied to the printing office for it in 1884. He thinks that the title page was received with the index. (Letter to Hitchcock, Aug. 8, 1906.)

Dr. Barnhart in response to a request for an opinion has, after reviewing the facts, summed up the matter as follows: "(1) Most grass specialists were able to consult Fournier's work from 1881. (2) They regarded it as published (not in a trade sense, but from a botanical standpoint), and cited it accordingly. (3) If we do not accept 1881 as the date, we open the question, in the case of each Fournier name that found its way deviously into botanical literature between 1881 and 1886, whether it was adequately published or not. (4) We have enough questions relating to the adequacy of publication of plant names without needlessly burdening ourselves with such a large number of others. On the whole, therefore, I strongly favor 1881."

- Plants perennial.
- Plants caespitose..... 2. *C. multifidum*.
- Plants stoloniferous.
- Spikes dimorphous; sterile lemma cleft less than half way..... 3. *C. erectum*.
- Spikes not dimorphous; sterile lemma cleft nearly to the base..... 4. *C. stoloniferum*.
- Spikes consisting of more than 3 spikelets. (But including *B. uniflora*, which has but 1 spikelet.) (BOUTELOU, p. 363.)
- Spikelets pectinately arranged at maturity (Subgenus CHONDROSIMUM).
- Spikes normally less than 4.
- Spike 1.
- Plants annual.
- Spikes comparatively narrow. (North American)..... 1. *B. procumbens*.
- Spikes comparatively wide. (South American)..... 2. *B. simplex*.
- Plants perennial.
- Stoloniferous..... 3. *B. stolonifera*.
- Cespitose..... 4. *B. scorpioides*.
- Spikes normally 2, often 1 or 3, or even 4, seldom more than 4.
- Glumes tuberculate; rachis prolonged beyond the spikelets as a naked point.^a
- Internodes hirsute-villous..... 5. *B. hirticulmis*.
- Internodes not hirsute-villous..... 6. *B. hirsuta*.
- Glumes not tuberculate; rachis not prolonged.
- Culms annual..... 7. *B. gracilis*.
- Culms in part perennial.
- Culms erect-branching..... 8. *B. breviseta*.
- Culms geniculate-branching..... 9. *B. ramosa*.
- Spikes normally 4 or more.
- Glumes hairy-villous..... 10. *B. parryi*.
- Glumes not hairy-villous.
- Plants annual.
- Awns of fertile lemma comparatively short..... 11. *B. barbata*.
- Awns of fertile lemma comparatively long..... 12. *B. arenosa*.
- Plants perennial.
- Low, 10 to 30 cm. high.
- Rudiment naked..... 13. *B. trivii*.
- Rudiment hairy-tufted..... 14. *B. sonorae*.
- Larger plants 30 to 50 cm. high.
- Culms villous; stoloniferous..... 15. *B. eriopoda*.
- Culms not villous; caespitose.
- Base delicate..... 16. *B. rothrockii*.
- Base strong, harsh, scaly, rhizomatous..... 17. *B. karwinskii*.

^a Forms of *B. gracilis* have tuberculate glumes, but never a prolonged rachis.

Spikelets not pectinately arranged.^a (Subgenus

ATHEROPOGON.)

Spikes of 1 spikelet..... 35. *B. uniflora*.

Spikes of more than 1 spikelet.

Plants annual.

Leaves and sheaths tuberculate-hairy.... 18. *B. alamosana*.

Leaves and sheaths not tuberculate-hairy..... 19. *B. aristidoides*.

Plants perennial.

Sheaths densely hairy..... 20. *B. pringlei*.

Sheaths not densely hairy.

Glumes densely hairy.

Sterile lemma trifid, long-awned. 21. *B. chondrosioides*.

Sterile florets two or three, with well developed lemmas (variable)..... 22. *B. eludens*.

Glumes not densely hairy. (See continuation.)

(Continuation.)

Sterile florets distinctly 2 or more.

Plants stoloniferous 23. *B. megapotamica*.

Plants caespitose.

Plants low, hairy..... 24. *B. texana*.

Plants tall, smooth..... 25. *B. lophostachya*.

Sterile floret 1 or with additional rudimentary one.

Second floret trifid and naked, not glumaceous.

Lateral awns short.

Proximal spikelets not rudimentary..... 26. *B. acuminata*.

Proximal spikelets rudimentary..... 27. *B. vanedeni*.

Lateral awns nearly as long as central one..... 28. *B. americana*.

Second floret glumaceous.

Second floret mostly perfect, the first sterile.

Plants smooth 29. *B. repens*.

Plants more or less prominently papillose-hairy.

Spikes and spikelets alike (Continental America).

Plants stout with harsh rhizomatous base. 30. *B. radicata*.

Plants more delicate, caespitose or geniculate..... 31. *B. filiformis*.

Spikes and spikelets very variable (West Indies)..... 32. *B. heterostega*.

Second floret sterile, the first fertile.

Spikes about 12..... 33. *B. disticha*.

Spikes more numerous.

Spikelet with rudiment of a third floret..... 34. *B. pilosa*.

Spikelet with no rudiment of a third floret..... 36. *B. curtispindula*.

^a Immature forms of several species belonging here are likely to be looked for under *Chondrosium*.

TRIAENA H. B. K.

Triana H. B. K. Nov. Gen. & Sp. 1: 178. 1816. A monotypic genus based upon *T. racemosa*.

Inflorescence linear, racemose, the spikes arranged in two rows on opposite sides of a flattened axis but so twisted upon their short delicate peduncles as to appear unilateral; spikes consisting of a single 2-flowered spikelet and a prolonged rachis, the lower floret perfect, the upper reduced to a 3-awned rudiment.

1. *Triana juncea* (Desv.).

Triathera juncea Desv.; Beauv. Ess. Agrost. 40. pl. 9. f. 4. 1812. Beauvois's figures, although diagrammatic, appear to me well to characterize the plant. Desvaux^a distinguishes this from his *T. americana* which is *Aristida americana* L.

Triana racemosa H. B. K. Nov. Gen. & Sp. 1: 179. pl. 61. 1816. Easily identified from the figures and description. See also Roem. & Schult. Syst. Veg. 2: 421. 1817.

Eutriana triana Trin. Gram. Unifl. 239. 1824. Based upon *Triana racemosa* H. B. K.

Atheropogon triana Spreng. Syst. Veg. 1: 293. 1825. Based upon *Triana racemosa* H. B. K.

Atheropogon domingensis Spreng. Syst. Veg. 1: 293. 1825. Based upon *Triathera juncea* Desv.

Dineba cristata Presl, Rel. Haenk. 1: 293. 1830. The type, in the Bohemian National Museum at Prague, has been examined.

Triathera racemosa Desv. Opusc. 72. 1831. Based on *Triana racemosa* H. B. K. See also Roem. & Schult. Syst. Veg. 2: 421. 1817; Fourn. Mex. Pl. 2: 141. 1881.

Eutriana? cristata Kunth, Enum. Pl. 1: 281. 1833. Based upon *Dineba cristata* Presl.

Triathera gracilis Fourn. Mex. Pl. 2: 141. 1881. I have no hesitancy in referring this to *Triana juncea*, although Fournier says distinctly that his plant is not *Triana racemosa* H. B. K. Fournier cites "*Eutriana racemosa* Trin. Msc. in Herb. Petrop." as a synonym. All specimens so named by Trinius belong to *Bouteloua curtipendula*. The first specimen cited by Fournier is Berlandier's no. 1016 from Cuernavaca, Mexico. This number in the herbarium of the Muséum at Paris, as well as in the herbarium at Vienna, belongs here without doubt. The latter is labeled *Eutriana racemosa* Trin. (See *Eutriana racemosa* Trin.)

Bouteloua triana Scribn. Proc. Acad. Phila. 1891: 307. f. 2. b 1891. Based upon *Triana racemosa* H. B. K. See also Bull. Torrey Club 18: 314. 1891.

DESCRIPTION.

A caespitose, erect, sparingly hairy perennial, forming strong, conspicuous bunches among other grasses or more rarely continuous pure growths approaching a rough, bunched turf; culms sparingly branched, erect or when luxuriant geniculate, 40 to 50 cm. high; sheaths rather close, striate, covered with long, scattered, papillose hairs, these more numerous in plants of exposed places; blades narrow, comparatively short, the lower about 7 cm., the upper 5 cm. long, erect, acuminate, rigid, involute, smooth save for the regularly arranged, marginal, papillose hairs; panicle slender, racemose, 7 to 10 cm. long, the spikes bilateral but usually so curved on their peduncles as to appear unilateral; spikes variable in number, 20 to 70, about 7 mm. long at anthesis but becoming 10 to 12 mm. long by the development of the awns of the rudiment,

^a Journ. de Bot. 1: 67. 1813.

^b In Beal's Grasses of North America (2: 427. 1896) this figure is incorrectly transferred to *B. texana*.

consisting of one spikelet, the rachis prolonged 1 to 2 mm. beyond; spikelet 2-flowered, the lower floret perfect, the upper reduced to a 3-awned rudiment; glumes minutely hispidulous on the keel, acuminate, the first 2 to 3 mm., the second 4 to 5 mm. long, very short-awned or merely acuminate; lemma ovate, indistinctly 3-nerved, especially below, 3-toothed at the apex, rarely awned; palet 2-nerved with 2 short awns at the apex; rudiment consisting of 3 scabrous awns about 7 mm. long, upon a naked stipe 3 mm. long; caryopsis not seen. (FIGURE 19.)

This species is common upon the highlands of central Mexico, especially from Hidalgo to Oaxaca, and extends far into Guerrero and western Jalisco. It is well represented in herbaria by *Pringle* 7482, 870, and 9573, and *Nelson* 1842, which are typical. Miguel Bang's no. 1307 in *Plantae Bolivianae*, from Sorata, Bolivia (distributed by Britton and Rusby), and Schop's no. 740 are both immature. The latter probably belongs here, but the former is doubtfully referred to this species.

HERBARIUM SPECIMENS.

MEXICO: *Pringle* 9573, El Salto; 8708, near Jojutla; 4792, Los Sedas, Oaxaca. *Nelson* 1842, Domingillo; 1542, Valley of Oaxaca. *Conzatti & Gonzalez* 265, Los Sedas. *Schott* 740, Yucatan.

PENTARRHAPHIS H. B. K.

Pentarrhaphis H. B. K. Nov. Gen. & Sp. 1: 177. pl. 60. 1816. A monotypic genus based upon *P. scabra*.

Polyschistis Presl, Rel. Haenk. 1: 294. pl. 41. f. 12-18. 1830. Based upon *P. paupercula*.

Strombodurus Willd.; Steud. Nom. Bot. ed. 2. 2: 299. 1841. This is listed as a synonym of *Pentarrhaphis*, and the single species *S. gracilis* Willd. is referred (page 647) to *Pentarrhaphis scabra* H. B. K. (The initial letter of the latter generic name is misprinted "D".)

Species with small, woolly spikes consisting of 2 spikelets, one of these sometimes aborted, approximate on a rachis ending in a forked or bifid prolongation; first glume of each spikelet reduced to scarcely more than a straight awn; these together with the bifid rachis appearing like a cluster of awns at the base of the spikelet; spikelets 2-flowered.

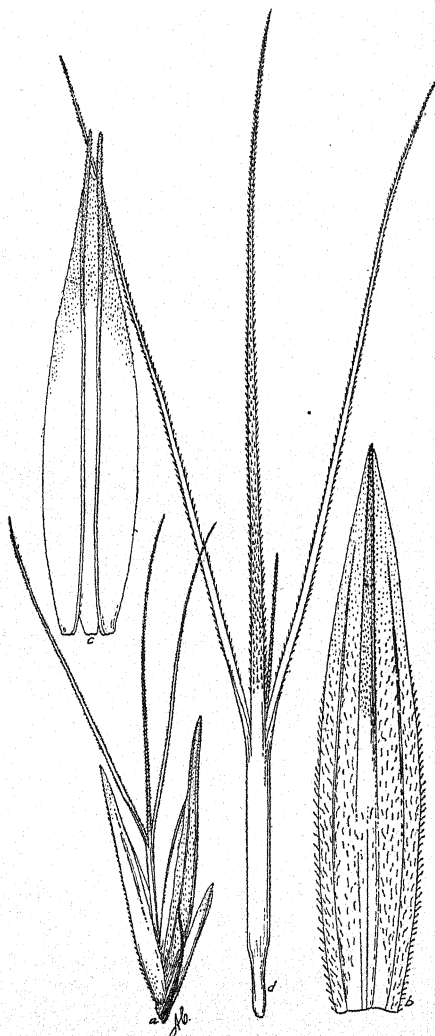


FIG. 19.—*Triaena juncea*. a, Spikelet; b, c, lemma and palet of first floret; d, rudiment. a, Scale 5; b-d, scale 10. From Griffiths 8122.

1. *Pentarrhaphis scabra* H. B. K.

Pentarrhaphis scabra H. B. K. Nov. Gen. & Sp. 1:178. *pl.* 60. 1816. Authentic material has not been found, but the figures are good and leave no room for doubt as to the identity of the species. See also Bull. Torrey Club 17:233. *pl.* 108. 1890.

Atheropogon pentarrhaphis Spreng. Syst. Veg. 1:294. 1825. Based upon *Pentarrhaphis scabra* H. B. K.

Eutriana pentarrhaphis Trin. Gram. Unif. 239. 1824. Based upon *Pentarrhaphis scabra* H. B. K.

Polyschistis pauperula Presl,^a Rel. Haenk. 1:294. *pl.* 41. *f.* 12-18. 1830. The figures and description identify the plant.

DESCRIPTION.

An erect, caespitose perennial about 30 cm. high; culms erect, commonly branched from the upper nodes; sheaths loose, striate, the ligule a short, dense fringe of white

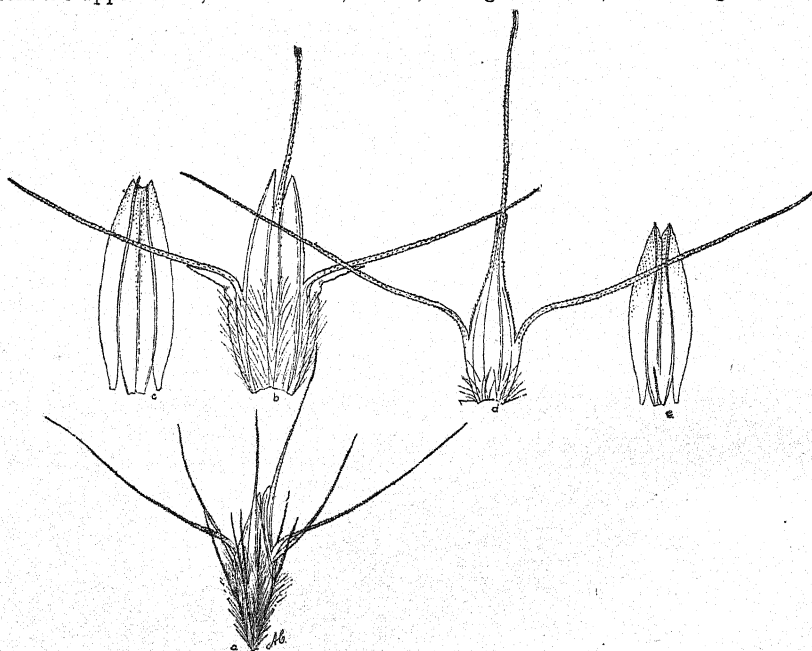


FIG. 20.—*Pentarrhaphis scabra*. *a*, Spike; *b*, *c*, lemma and palea of first floret; *d*, *e*, lemma and palea of second floret. *a*, Scale 5; *b*-*e*, scale 10. From Heyde & Lux 4659.

hairs; blades mostly radical, rather harsh, rigid, very slightly scabrous on the margin, the lower 4 to 5 cm. long, the upper reduced to 2 cm. long or less; panicle racemose, loose, 4 to 5 cm. long, the rachis zigzag; spikes about 12, small, 8 mm. long, including the awns, consisting of one perfect, 2-flowered spikelet and a cluster of awns below; cluster of awns consisting of 5 parts, 2 of these united below, representing the continuation of the rachis, one slightly expanded, representing the first glume of the perfect spikelet, the other two representing the aborted lower spikelet, all of these, together with the upper glume, densely white-hairy; lemma of the first floret, including awns, about 6 mm. long and of the second floret about 7 mm. long, both sparingly hairy, the upper coriaceous; palea slightly scabrous on the nerves, convolute, nearly 3 mm. long, scarcely awned; caryopsis not seen. (FIGURE 20.)

^a This is from tropical America instead of the Island of Luzon, as stated by Presl. See Merrill's opinion in the Philippine Journal of Science (1:380. 1906).

HERBARIUM SPECIMENS.

MEXICO: Nelson 2940, Chiapas.

GUATEMALA: Heyde & Lux 423, Santa Rosa.

2. *Pentarrhaphis polymorpha* (Fourn.).

Atheropogon polymorphus Fourn. Mex. Pl. 2: 141. 1881. A few spikes of the type before me identify this plant perfectly. Fournier had smaller plants, however, than any in the U. S. National Herbarium, as indicated by a photograph of the specimens in the herbarium of the Muséum at Paris.

Bouteloua fourneriana Vasey; Wats. Proc. Amer. Acad. 22: 461. 1887. A name only.

Pentarrhaphis fourneriana Hack. & Scribn. Bull. Torrey Club 17: 229. pl. 107, 108. 1890. Pringle's no. 2559 in U. S. National Herbarium is a duplicate of the type.

Pentarrhaphis geminata Hack. & Scribn. Bull. Torrey Club 17: 230. 1890. A name only.

• DESCRIPTION.

An erect, smooth, caespitose perennial, about 30 cm. high, with the habit of well-developed plants of *B. trinitii*, but larger throughout; culms mostly erect, but in some

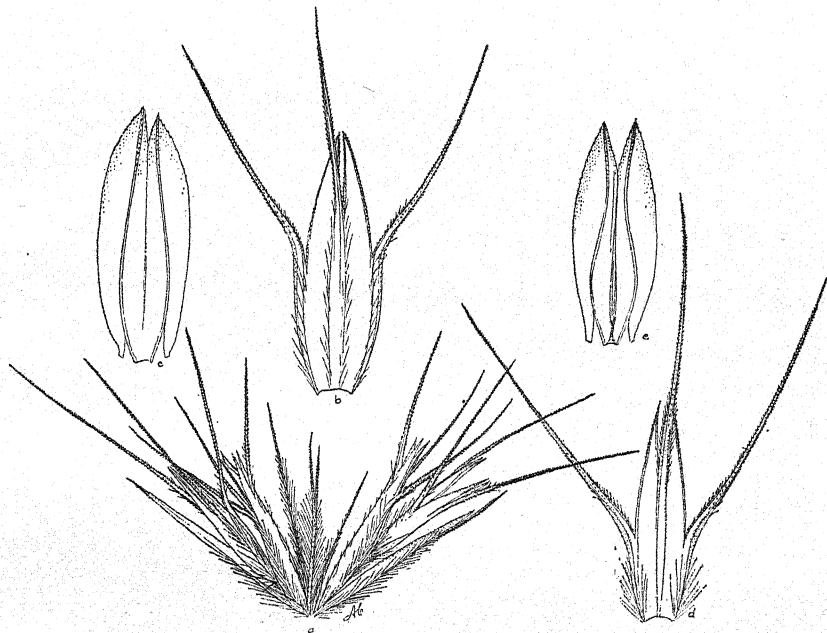


FIG. 21.—*Pentarrhaphis polymorpha*. a, Spike displayed; b, c, lemma and palea of first floret; d, e, lemma and palea of second floret. a, Scale 5; b-e, scale 7.5. From Pringle 2559.

specimens inclined to be slightly geniculate; upper blades sparse, flat, and short, the lower more abundant and longer, 5 to 10 cm. long and about 1 mm. wide, bearing a few minute, scattered hairs on both surfaces; sheaths striate, smooth, narrow, the ligule reduced to a ciliate fringe; panicle racemose, the rachis wavy or zigzag; spikes 4 to 8, triangular, 6 to 10 mm. long, purplish in all the specimens at hand; spikelets with backs together, 2-flowered, the lower floret pistillate, the upper staminate, with a bifid or undivided awn-like rudiment of a third; glumes narrow, the lower reduced to little more than an awn about 4 mm. long, the upper wider, keeled, notched above, 5 to 6 mm. long; lemma 5 to 6 mm. long, including the 3 nearly equal awns, the glumes and lower lemma covered with white hairs 1 mm. long; palea 3 to 4 mm. long, deeply

cleft and bearing 2 short awns; palet and upper floret smooth; behind the palet of the upper floret, a short awn, 1 mm. long, the prolongation of the rachilla; caryopsis not seen. (FIGURE 21.)

The species has not often been collected. In the U. S. National Herbarium, *Pringle* 2559, 11242, 5398, and *Palmer* 200, all from the State of Jalisco, Mexico, are representative. *Palmer* has also collected it near Durango, Mexico. *Rose's* no. 1621, Sinaloa, and *Rose & Hough* 4775, Jalisco, are typical.



FIG. 22.—*Cathestecum prostratum*. a, Sheath with inflorescence protruding, showing two spikes, one with 3 spikelets, the other with the lower pair of spikelets aborted; b, uppermost spikelet; c, d, lemma and palet of first floret; e, f, lemma and palet of second floret; g, h, lemma and palet of third floret; i, lemma of fourth floret; j, one of lower pair of spikelets; k, l, lemma and palet of first floret; m, n, lemma and palet of second floret. a, Scale 5; b-n, scale 7.5. Fr m type specimen.

CATHESTECUM Presl.

Cathestecum Presl, Rel. Haenk. 1: 294. pl. 42. 1830. Based upon *C. prostratum*. Bentham and Hooker^a write the name "*Cathestechum*."

Inflorescence racemose, with 4 to many spikes, each consisting of 3 approximate spikelets, the first glume of each spikelet, or at least of the terminal one, more or less reduced, commonly to a nerveless fimbriate scale, the lemmas of the upper florets showing a tendency toward branching, or sometimes an actual multiplication of nerves and awns by division of the typical lateral nerves.

^aGen. Pl. 3: 1122. 1883.

1. *Cathestecum prostratum* Presl.

Cathestecum prostratum Presl, Rel. Haenk. 1: 295. pl. 42. 1830; Steud. Syn. Pl. Glum. 1: 201. 1854; Fourn. M^x. Pl. 2: 133. 1881; Hemsl. Biol. Centr. Amer. Bot. 3: 517. 1885. The following set of characters is drawn from a panicle of the type before me: Spikes 4 to 6, small, about 2.5 mm. wide and 4 mm. long, or, including the awns of the upper spikelets, 8 mm. long, the rachis prolonged into a bifid awn 2 mm. long, the lower pair of spikelets always aborted and often reduced to little more than the glumes, always short-awned; third spikelet, 2-flowered, with a rudimentary third floret, the first floret pistillate; glumes narrow, awned, densely hairy, the first one of the third floret reduced to a blunt, comparatively wide, nerveless scale less than 1 mm. in length; lemma of third spikelet about 4 mm. long, including the slightly unequal awns, slightly hairy above, with subulate acute lobes; palet



FIG. 23.—*Cathestecum prostratum*. a, Spike; b, uppermost spikelet and prolongation of rachis; c, d, lemma and palea of first floret; e, f, lemma and palea of second floret; g, h, lemma and palea of third floret with prolongation of rachilla attached; i, one of lower pair of spikelets; j, k, lemma and palea of first floret; l, m, lemma and palea of second floret. a, Scale 5; b-m, scale 7.5. From Pringle 8707.

2-nerved, with edges incurved, scarcely awned; lemmas of second floret and rudiment of third, with longer, more prominently hirsute awns and rounded, very deeply divided lobes.

DESCRIPTION.

A tufted annual, about 20 cm. high; culms variable, erect, geniculate or half-prostrate, branching at the nodes; sheaths loosely inclosing the main culm and its branches, the ligule reduced to a delicate fringe of flexuous, white hairs; blades few, short, 3 to 5 cm. long, 1.5 mm. wide, the upper subulate, about 1 cm. long; panicle loosely racemose, with a zigzag flattened axis about 3 cm. long; spikes 4 to 8, triangular rhomboidal, about 8 mm. long; lower or lateral spikelets about 4 mm. long, the central or upper one about 6 mm. long, the two lateral 2-flowered and apparently both always staminate, the upper central spikelet consisting of one lower pistillate and two upper staminate florets and a club-shaped or bifurcated prolongation of the rachilla, about 1 mm. long, behind the palea of the third floret; second glume of each

spikelet densely covered with long straight hairs, that of each lateral spikelet about 3 mm. and of the upper one about 4 mm. long, the first glume of each lateral spikelet less hairy and only 2 mm. long, that of the upper spikelet reduced to a broad fan-shaped, nerveless scale scarcely 1 mm. in length; lemmas of the lower spikelets sparsely short-hairy, coriaceous, 2 to 3 mm. long, short-awned; palets convolute, 2-nerved, slightly scabrous at the tip, not awned; awns of palet of third spikelet about 2 mm. long and more scabrous, the parts of the third floret much reduced; caryopsis not seen. (FIGURES 22, 23.)

The above description is drawn from Pringle's no 8707, upon which the large spikes are by far the most abundant, but upon the same specimens there are other spikes which are the same as those of the type.

The Haenke specimen is uniform in having small spikes with the lateral spikelets more or less aborted. The Pringle specimen, on the contrary, shows the species to be dimorphic.

Fournier refers one of Schaffner's specimens without locality to this species, but I have seen only the fragment of the type mentioned above and *Pringle* 8707, collected

on limestone hills near Jojutla, Morelos, Mexico.

It is more than likely that the description will have to be modified somewhat in the future, for all specimens seen are immature.

2. *Cathestecum multifidum* sp. nov.

DESCRIPTION.

A delicate, upright, hairy, caespitose perennial, about 40 cm. high; culms erect, delicate, simple; sheaths striate, close, with a few scattered hairs above; ligule a fringe of a few long white hairs; blades abundant below, flat, long and

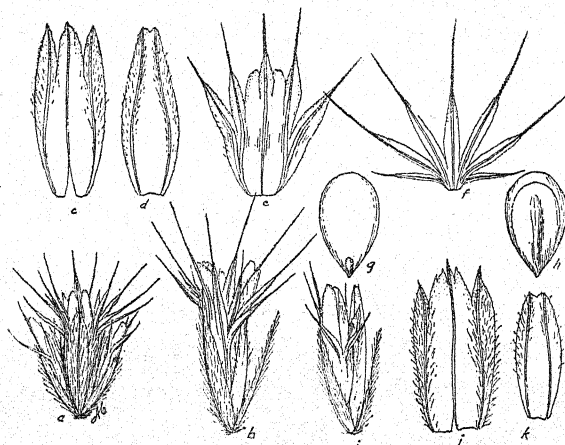


FIG. 24.—*Cathestecum multifidum*. a, Spike; b, uppermost spikelet; c, d, lemma and palea of first floret; e, f, lemmas of second and third florets; g, h, two views of caryopsis; i, one of lower pair of spikelets; j, k, lemma and palea of lower floret. a, Scale 5; b-f, scale 7.5; g-i, scale 10; j, k, scale 7.5. From type specimen.

narrow, 10 to 15 cm. long, a trifle over 1 mm. wide, the upper reduced, thinly beset with long, straight or flexuous, white hairs, 2 to 3 mm. long, arising from papillae; panicle racemose, 5 to 6 cm. long, on a zigzag axis; spikes about 15, small, 4 to 5 mm. long over all, roughly triangular in outline, the rachis prolonged as a barbed, simple or bifid awn, usually less than 2 mm. long, with or without a very small winged expansion on one side; lateral spikelets 2-flowered, the rachilla prolonged into a blunt or bifid awn behind the palea of the second floret, or often the upper floret aborted and reduced to a bunch of awns upon a naked stipe; central spikelet 2-flowered, with a well-developed third floret consisting of 6 to 10 expanded awns on a naked stipe; glumes pubescent, narrow, acuminate or short-awned, the first about 2 mm. long, the upper about 3 mm. long; lemma of the lower floret about 2.5 mm. long over all, bearing a few scattered hairs, 3-nerved, 3-awned, the awns very short; palea plicate, about 2.5 mm. long, scarcely awned; lemma of the second floret becoming 5 to 7-awned by the splitting of each of the normal lateral nerves into 2 or 3, 3 to 5 mm. long; lower floret of upper spikelet apparently pistillate only, the others staminate; caryopsis not seen. (FIGURE 24.)

The type of this species was collected by myself at Iguala, Mexico, September 9, 1909. It was later collected at Oaxaca, Mexico, by Hitchcock (no 6164). It is an

abundant and conspicuous plant, easily recognized by its long, delicate, graceful culms, small spikes, tufted habit and narrow, flat, hairy, abundant leafage. In minuter details it differs from all other species of the genus in having the lateral awns of the lemmas of the second floret split into 2, making a well-developed 5-awned lemma, while the lower florets are typically 3-awned, and the lateral awns of the lemma of the third floret and rarely of the second also are split into 3, making it 7-awned and 7-nerved.

It is very probable that this characterization will have to be modified when mature material becomes available, for the above collections are of plants in bloom only.

3. *Cathestecum erectum* Vasey & Hack.

Cathestecum erectum Vasey & Hack. Bull. Torrey Club 11: 37. pl. 45. 1884. The Havard specimens from Presidio County, western Texas, no. 30, 1881, and no. 2, 1883, are in the U. S. National Herbarium, together with the Palmer specimen from Sonora, Mexico, 1869, which is the first mentioned. There is a note on Havard's no. 30 in

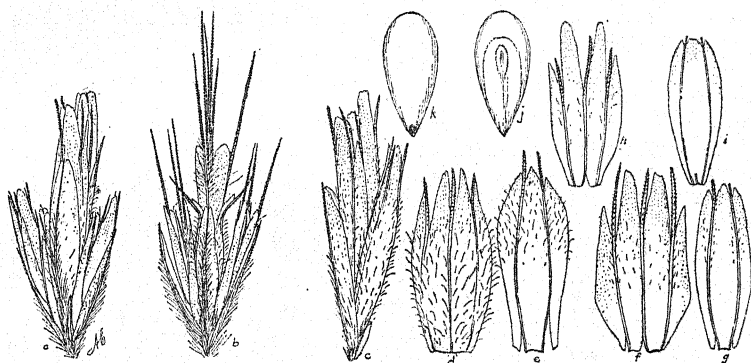


FIG. 25.—*Cathestecum erectum*. a, b, Short and long-awned forms of spikelet; c, uppermost spikelet of a; d, e, lemma and palet of first floret; f, g, lemma and palet of second floret; h, i, lemma and palet of third floret; j, k, two views of caryopsis. a, b, Scale 5; c-i, scale 7.5; j, k, scale 10. From Griffiths 6834.

Vasey's hand, "—17 Dr. Palmer 1869." See also U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 13. 1890; Contr. Nat. Herb. 2: 536. 1894.

This is the species described and figured ^a by Scribner under the name *Cathestecum prostratum* Presl.

DESCRIPTION.

A sparsely hairy, erect, stoloniferous perennial of variable habit, 5 to 40 cm. high; culms erect or geniculate and rooting at the prominently hairy nodes, simple or branched; sheaths sparsely hairy, the ligule a line of long white hairs; blades flat, very variable, abundant below, shortened upward, bearing a few scattered hairs like those on the sheaths, scabrous-margined; panicle racemose, 3 to 5 cm. long, the apex of the axis minutely bifurcated; spikes 6 to 8, about 8 mm. long, rather thin, but not especially lax; the upper spikelet perfect, the lateral pair rudimentary; lower florets of the lateral spikelets with well developed but sterile lemmas; second floret staminate or neuter, the upper rudimentary; first glume of each spikelet reduced to a short, truncate, nerveless scale, the second long, lanceolate, keeled, hairy, mucronate, 3 to 4 mm. long; lemma coriaceous, smooth, with awns and lobes about equal, but the awns slightly longer, in the upper florets the lobes deeper and the awns with long hairs below; palea slightly shorter than the fertile lemma, plicate, short-awned; caryopsis obovate, 1.5 mm. long, flattened, the scutellum covering about three-fourths the ventral surface. (FIGURE 25.)

^a U. S. Dept. Agr. Div. Agrost. Bull. 7: 242. f. 224. 1897.

The above characterization is drawn from the short-awned form which corresponds with the type.

This species is variable. Hitchcock's no. 6776 from Balsas, Mexico, is very different in color, especially from the northern Sonora plants.

In 1904 between Imuris and Santa Ana in the State of Sonora I collected under no. 6834 two more or less distinct forms. One, which grew in a favorable depression, is tall and rank, with abundant leafage, and is short-awned. The other, which grew on a contiguous gravelly knoll, shows both short and long-awned forms, but on separate plants.

Collections have commonly included both forms under the same number. But one thing is peculiar—the two forms are seldom found on the same plant. Both forms produce seed and in exactly the same relative position. Pringle's no. 4559 contains both forms, but the long-awned one has the spikes greatly reduced, the two lower spikelets being very much aborted. Palmer's nos. 1261 of 1891 and 705 of 1890 show both forms also. Not until Hitchcock's 1910 collections from Mexico came in were the two forms found on the same plant. This does not appear to be a case of lengthening of the awns after anthesis, as with *Bouteloua chondrosioides*, but a true dimorphic character. The species is distributed from the Rio Grande region of western Texas to Arizona and southward to the state of Colima.

Palmer's no. 345 of 1887 from Guaymas, Mexico, has a habit which is unique. The culms instead of being geniculate-stoloniferous are erect-proliferous with the same knotty appearance at the nodes, but perfectly erect and not rooting.

HERBARIUM SPECIMENS.

TEXAS: *Havard* 30, and 2, El Paso to Presidio. *Nealley*, Chenata.

MEXICO: *Palmer* 18, Yaqui River, Sonora; 345, 161, Guaymas; 66, Chihuahua; 270, Guadalajara; 126, 112, Colima; 705, Alamos; 1460, 1459, Ymala. *Pringle* 597, Altar; 4559, Tequila. *Hitchcock* 3528, Llano. *Brandegge* 1, 2, Culiacan.

4. *Cathestecum stoloniferum* (Fourn.).

Atheropogon stolonifer Fourn. Mex. Pl. 2: 140. 1881. The type is *Liebmann* 588, "La Parada, Sierra de Oajaca." As this specimen has not been examined, the description and cited locality are our only guide. The name is appropriate and the description fits the plants referred here. Fournier's characterization of spike details, however, is not so satisfactory.

DESCRIPTION.

A low, creeping, stoloniferous perennial, 10 to 15 cm. high, forming at times a moderate turf; culms erect or geniculate, 10 to 15 cm. high, with stolons rooting readily and bearing small tufts of leaves at intervals of 8 to 10 cm.; sheaths short, striate, smooth, the nodes smooth except when geniculate and then hairy, the ligule consisting of a few, long, white hairs; spikes 4 to 6, triangular in general outline and about 13 mm. long; first floret pistillate, the second staminate, with or without one or two rudimentary additional ones, the latter always more numerous and better developed in the upper central spikelet; glumes of lower spikelets densely hairy, narrow, keeled, acuminate, short-awned, the lower more than 2 mm., the upper more than 4 mm. long, the lower glume of the upper spikelet reduced to a nerveless fan-shaped, fimbriate scale scarcely 1 mm. long; lemma of the lower floret coriaceous, pubescent, about 6 mm. long including the awns; central awn about 2 mm. longer than the lateral; lateral awns of the lower spikelets often unequal in the second floret,

the third floret when present bearing equal awns, the lemma being very deeply lobed and cut, the lateral awns appearing almost separated; palet plicate, very shortly 2-awned; caryopsis obovate, 1.5 to 2 mm. long, with conspicuous embryo and scutellum covering practically the entire ventral surface. (FIGURE 26.)

The species is very abundant in the canyon of Tomellín, where it constitutes the main pasturage over extensive areas and whence it extends to the valley of Oaxaca. It makes a semblance of a turf in places and in habit very closely resembles *Hilaria cenchroides*.

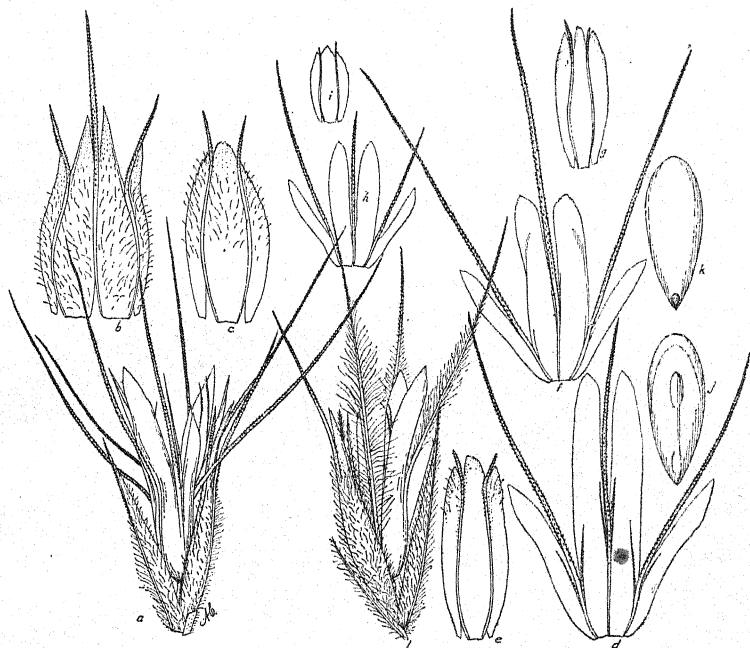


FIG. 26.—*Cathetecum stoloniferum*. a, Uppermost spikelet; b, c, lemma and palet of first floret; d, e, lemma and palet of second floret; f, g, lemma and palet of third floret; h, i, lemma and palet of fourth floret; j, k, two views of caryopsis; l, one of lower pair of spikelets. a-i, Scale 7.5; j, k, scale 10; l, scale 7.5. From Griffiths 8122.

The only specimen referred here, aside from collections by myself and Hitchcock listed elsewhere,^a is no. 958, collected by C. L. Smith at San Antonio, valley of Oaxaca, Mexico.

BOUTELOUA Lag.

Bouteloua Lag. Var. Cienc. 2⁴: 134. 1805. Based upon *B. racemosa*.

Atheropogon Muhl.; Willd. Sp. Pl. 4: 937. 1806. Based upon *A. aphudioides*.

Triathera Desv. Nouv. Bull. Soc. Philom. Paris 2: 188. 1810. Based on *Aristida americana*.

Heterosteca Desv. Nouv. Bull. Soc. Philom. Paris 2: 188. 1810. Based upon *H. juncifolia* from "Antillis." See also H. B. K. Nov. Gen. & Sp. 1: 173. pl. 54. 1816. The name is written by Kunth^b "*Heterostega*," and by Hooker^c "*Heterostegon*."

^a See page 425.

^b Mém. Mus. Hist. Nat. 2: 73. 1815.

^c Trans. Linn. Soc. Bot. 20: 175. 1847.

Chondrosium Desv. Nouv. Bull. Soc. Philom. Paris 2: 188. 1810. Based upon *Chloris procumbens* Durand.

Actinochloa Willd.; Beauv. Ess. Agrost. 41. 1812. "*A. tenuis* Willd. manuscript" mentioned as a synonym of *Chondrosium*. See also Roem. & Schult. Syst. Veg. 2: 417. 1817. Based upon *Chondrosium procumbens* Desv.

Dineba Beauv. Ess. Agrost. 98. 1812. In listing the genera in which the species of his proposed genus have been placed Beauvois gives after "*Dineba* DELL.," *Aristida* first and without doubt had in mind *A. americana* L. In listing the species he places "*D. arabica* (*Cynosurus retroflexus* ? Lin.)" first and "*Aristida americana* Lin.," following. In his illustrations he gives *D. curtipendula* first, followed by *D. arabica* and *D. americana*. Delile ^a figures under *D. aegyptiaca* the same plant as does Beauvois under *D. arabica*. But this species does not belong to this group. (See list of excluded names, p. 423.)

Polyodon H. B. K. Nov. Gen. & Sp. 1: 174. pl. 55. 1816. This is a monotypic genus based upon *F. distichum*.

Eutriana Trin. Fund. Agrost. 161. 1820. Based upon *Chloris curtipendula* Michx. *Aristidium* (Endl.) Lindl. Veg. Kingd. 116. 1846. *Eutriana*, section *Aristidium* Endl.,^b based on *Dinebra aristidoides* H. B. K. (misspelled "aristoides"), is listed as a genus by Lindley.

Triplathera (Endl.) Lindl. Veg. Kingd. 116. 1846. *Eutriana*, section *Triplathera* Endl.,^c based on *Eutriana multisetia*, is listed as a genus by Lindley.

Antichloa Sweet; Steud. Nom. Bot. ed. 2. 1: 108. 1840. The same as "*Actinochloa*"; a name only.

Nestlera Willd.; Steud. Nom. Bot. ed. 2. 2: 192. 1841. Based upon *N. festucaeformis* of Willdenow Herbarium, which is *Bouteloua bromoides*, i. e., *B. radicata*, according to the Index Kewensis; names only.

Erucaria Cervantes, La Naturaleza (Mexico) 347. 1870. (See list of excluded names, p. 424.)

"*Chondrosia* or *Chondrosium* Desv.;" Benth. Journ. Linn. Soc. Bot. 19: 104. 1881. Simply a discussion of the general divisions of the group and a mention of *Bouteloua racemosa* Lag. as the best-known species.

Very variable in every detail; spikes one to 60; spikelets more than 3,^d pectinate or not, 2 to several-flowered, mostly 1-flowered, with one or more rudiments; the lemmas 3-nerved, 3-awned, the paleas 2-nerved, 2-awned.

1. *Bouteloua procumbens* (Durand).

Chloris procumbens Durand, Chlor. Sp. 1808. I am able to verify the opinions of some of the older authors from a copy of the original description kindly furnished by the Director of the Kew Gardens.

Chondrosium procumbens Desv. in Beauv. Ess. Agrost. 41. pl. 9. f. 7. 1812. Based on "*Chloridis spec.* DURAND." Desvaux ^e also gives this, the only species, under his genus *Chondrosium*, with *Chloris procumbens* Durand as a synonym.

Atheropogon procumbens Jacq. Ecllog. Gram. 16. pl. 12. 1813. (Copy in Gray Herbarium.) The illustrations and description are good. *Chloris procumbens* Durand is cited as a synonym.

Bouteloua prostrata Lag. Gen. & Sp. Nov. 5. 1816. A specimen from Lagasca in the herbarium at Munich appears to belong here, but the single culm before me has two spikes, which is the unusual form of the species. Lagasca listed this species

^a Descr. Egypte 26. pl. 11. f. 3. 1813.

^b Gen. Pl. 94. 1836.

^c Trans. Linn. Soc. Bot. 20: 175. 1847.

^d An exception is found in *B. uniflora* which has one spikelet in a spike.

^e Journ. de Bot. 1: 69. 1813.

without description in an earlier^a paper. See also U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 42. 1890.

Chondrosium tenue Willd.; Beauv. Ess. Agrost. 158. 1812. Beauvois publishes "*Actinochloa tenuis* Willd. mss." on page 41 and makes the above combination in his index on page 158. He, however, gives no description. In his private copy of the above-cited work he has written "= *Bouteloua simplex* Lag. and *Actinochloa*, Roemer." See also H. B. K. Nov. Gen. & Sp. 1: 176. pl. 57. 1816. Plainly distinguishable by the figure and description.

Actinochloa procumbens Roem. & Schult. Syst. Veg. 2: 417. 1817. Based upon *Chloris procumbens*.

Actinochloa tenuis Willd.; Roem. & Schult. Syst. Veg. 2: 418. 1817. *Chondrosium tenue* H. B. K. is cited as a synonym.

Actinochloa prostrata Roem. & Schult. Syst. Veg. 2: 419. 1817. Based upon *Bouteloua prostrata*.

Eutriana tenuis Trin. Gram. Unif. 240. 1824. Based upon *Actinochloa tenuis* Willd. *Chloris filiformis* Poir.; Kunth, Rév. Gram. 1: 93. 1829. Mentioned as a synonym of *Chondrosium tenue*.

Chloris tenuis Poir.; Kunth, Rév. Gram. 1: 93. 1829. A herbarium name cited as synonym of *Chondrosium tenue*.

Chondrosium? prostratum Kunth, Rév. Gram. 1: 94. 1829. Based upon *Bouteloua prostrata* Lag. See also Sweet. Hort. Brit. 1: 455. 1826; Fourn. Mex. Pl. 2: 138. 1881.

Bouteloua tenuis Griseb. Abh. Ges. Wiss. Göttingen 19: 211. 1874. (Plantae Lorentzianae.) Based upon *Chondrosium tenue*.

Bouteloua pusilla Vasey, Bull. Torrey Club 11: 6. 1884. The type, in the National Herbarium, was collected by Vasey at Kingman, New Mexico, June, 1881.

DESCRIPTION.

A small, smooth, caespitose, prostrate or ascending, sparingly branched, annual, attaining its best development above an altitude of 1,600 meters; sheaths smooth, striate, with reduced, shortly pubescent ligules and few narrow blades only 2 to 3 cm. long; spikes solitary, 1.5 to 2 cm. long, revolute toward maturity, fertile to the end of the rachis; spikelets consisting of one lower fertile floret and an upper rudiment; glumes keeled, acuminate, pointed but awnless, the first smooth, about 3 mm. long, the second minutely hispid on the keel and 4 to 5 mm. long; lemma broadly oval, with 3 hispid, unequal awns, the central the longest and expanded with wing-like projections below; palea broadly obovate, smooth, broadly rounded above, about 3 mm. long, rudiment consisting of 3 equal, hispid awns, about 4 mm. long, together with 2 or 3 very small scales upon a naked stipe bearing a tuft of white hairs at its apex; caryopsis about 2 mm. long, 0.75 mm. wide, obovate, the scutellum covering the entire ventral and curving back over a portion of the dorsal surface. (FIGURE 27.)

When thinly distributed, especially upon loose fertile soils, this species forms large bunches which are more likely to be prostrate than when the plants are crowded and smaller.

As a forage plant it is of very little value on account of its diminutive size and the ease with which it pulls up when grazed. Indeed, it has never been met with in sufficient abundance to be much of a factor in feed production.

Specimens representing my conception of the species are *Pringle* 6450, 11218, *Palmer* 176, 332, 503, 712, *Metcalf* 583. *Pringle* 1434, Chihuahua, and 6450, Federal District of Mexico, and *Schaffner* 156, San Luis Potosí, approach the heavy-spiked

^a Var. Cienc. 2⁴: 141. 1805.

form of South America treated as *B. simplex*. Indeed, the last is almost a perfect match for some of the South American forms. The species has a very wide distribution, extending from Colorado southward, its place being taken by *B. simplex* in South America, if indeed the latter is distinct.

In South American specimens the spikes are commonly two or more at the end of some culms, this form thus approaching the genus *Chloris*. This condition is rare in North American specimens, if those examined and collected are typical, but is sometimes found, however, in *B. procumbens*, as shown sparingly by *Griffiths* 9516, collected in the vicinity of Prescott, Arizona.

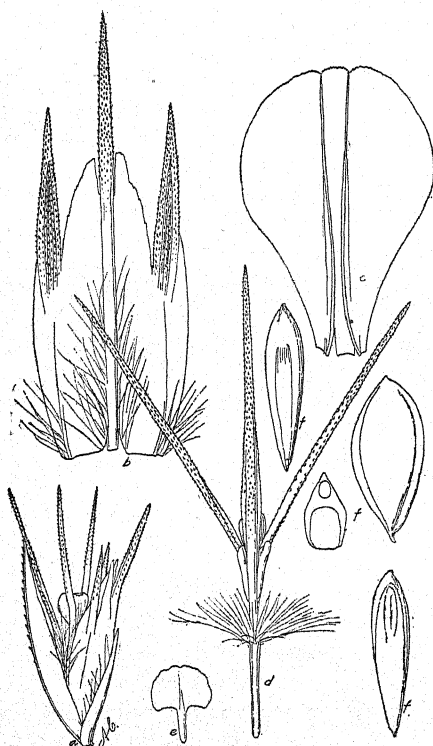


FIG. 27.—*Bouteloua procumbens*. a, Spikelet; b, c, lemma and palea of first floret; d, rudiment of second floret; e, rudiment of third floret; f, three views and cross section of caryopsis. a, Scale 7.5; b-f, scale 12.5. From *Griffiths* 7362.

HERBARIUM SPECIMENS.

ARIZONA: *Leiberg* 5897, San Francisco Mountains.

COLORADO: *Chase* 2569, South Cheyenne Canyon; 6500, Pikes Peak Region; 5395, Harbert Ranch to Wet Canyon, Spanish Peaks. *Shear* 1262, Durango. *Hitchcock* 1771, Manitou.

MAINE: *Parlin* 1514, New Brunswick, introduced in sheep wool.

NEW MEXICO: *Wootton* 2925, Encinada. *Wootton & Standley* 3523, Lincoln County; 5049, San Miguel County; 212, Lincoln County. *Metcalfe* 1502, Kingston, 583, Socorro County. *Baker* 90 and 163, Chama. *Jones* 4348, Grants.

UTAH: *Jones* 5995, Panguitch.

MEXICO: *Pringle* 1434, plains of Guerrero; 6450, Pedregal, Valley of Mexico; 13242, mesas near Zontecomate, Hidalgo; 11218, Federal District. *Palmer* 3, Chihuahua; 480, Guadalajara; 176, Alvarez; 332, near Saltillo; 397, 398, Saltillo; 712, Durango. *Schaffner* 1016, 156, San Luis Potosi.

2. *Bouteloua simplex* Lag.

Bouteloua simplex Lag. Var. Cienc. 2⁴: 141. 1805. There is a specimen in the herbarium of the Madrid Botanical Garden named *Bouteloua simplex* by Lagasca.

Chondrosium humile Beauv. Ess. Agrost. 158. 1812. A name only listed in the index and based on *Actinochloa humilis*, a manuscript name of Willdenow published without description on page 41; H. B. K. Nov. Gen. & Sp. 1: 175. pl. 56. 1816. The figures and description in the last work are sufficient to identify the species.

Actinochloa humilis Willd.; Roem. & Schult. Syst. Veg. 2: 417. 1817. Based upon *Chondrosium humile* H. B. K.

Actinochloa simplex Roem. & Schult. Syst. Veg. 2: 418. 1817. Based upon *Bouteloua simplex* Lag.

Atheropogon humilis Spreng. Syst. Veg. 1:293. 1825. Based upon *Chondrosium humile* H. B. K.

Eutriana humilis Trin. Gram. Unifl. 239. 1824. Based upon *Actinochloa humilis* Willd.

Chondrosium? simplex Kunth, Rév. Gram. 1:94. 1829.

Based upon *Bouteloua simplex* Lag.

Bouteloua humilis Hieron. Bol. Acad. Cienc. (Córdoba) 4:495. 1882. Based upon *Chondrosium humile* Beauv.

Bouteloua brachyathera Philippi, Anal. Mus. Nac. Chile (Bot.) 8:85. 1891. The type, no. 287 of Philippi's herbarium, has been examined.^a

Bouteloua rahmeri Philippi, Anal. Mus. Nac. Chile (Bot.) 8:85. 1891. Herb. Philippi, no. 268, Province of Terapaca, Chile, is the type. It has been through my hands and I find it a very good match for a specimen in the U. S. National Herbarium collected by Rusby (no. 34) near Yungos, Bolivia, in 1885.

DESCRIPTION.

A prostrate or ascending, spreading, smooth annual, 20 to 25 cm. high; culms geniculate or ascending, seldom branched; sheaths smooth, deeply striate, rather loose, the ligule a conspicuous ring of short, white hairs; blades not abundant, short, narrow and inclined to be involute, about 3 cm. long; spikes terminal, normally 1 but some-

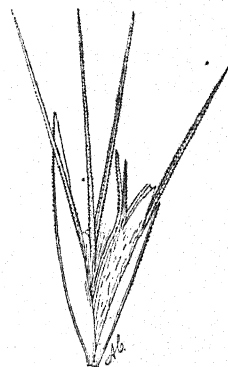


FIG. 28.—*Bouteloua simplex*. Spikelet. Scale 7.5. From typespecimen of *B. rahmeri*.



FIG. 29.—*Bouteloua simplex*. a, Spikelet; b, c, lemma and two views of palea of first floret; d, rudiment. a, Scale 7.5; b-d, scale 15. From type specimen of *B. brachyathera*.

times 2 to 4, congested at the apex of the culm, varying from 2 to 4 cm. long, straw colored to purplish-tinged; spikelets commonly about 50, about 8 mm. long, including the awns, pectinate, consisting of a lower perfect floret and a rudiment; glumes sharply and hispidulously keeled, otherwise smooth, the lower about 3 mm., the upper 5 to 6 mm. long; lemma, including awns, about 6 mm. long, covered on the back with a long, scattered pubescence, 3-awned, the central awn 2 mm. longer than the lateral; palea smooth, obovate, awnless; rudiment consisting of 3 hispid awns, 5 or 6 mm. long, together with a few scales at base borne upon a hairy, tufted pedicel about 1 mm. long; caryopsis more or less triangular in vertical section, about 1.5 to 1.75 mm. long, slightly curved, the scutellum covering about two-thirds of the ventral surface. (FIGURES 28, 29.)

This description is drawn from Miguel Bang's no. 81, in the John Donnell Smith Herbarium, from the vicinity of La Paz, Bolivia, altitude 10,000 feet. The original

^a See discussion, p. 368.

description of the species is short: "culmo simplici, erectiusculo, monostachio: spica terminali, oblonga, glaberrima." This was written in 1805. In his later work,^a Lagasca added to this the two facts that the habitat of the plant is Peru and that it is an annual. These facts in connection with the above description satisfy me that



FIG. 30.—*Bouteloua stolonifera*. a, Spikelet; b, c, lemma and palet of first floret; d, e, rudimentary lemma and palet of second floret; f, g, rudimentary third and fourth florets. a, Scale 7.5; b-g, scale 10. From type specimen.

Lagasca had the South American form of what he described in the next paragraph as *B. prostrata*. Philippi gave two names to this species. His *B. brachyathera* is a single-spiked immature plant, but unmistakably this species. The type of his *B. rahmeri* is fragmentary and immature, having 2 or 3 spikes aggregated at the apex

^a Gen. & Sp. Nov. 5. 1816.

of the culm. There are no differences between them in the spikelets and floral details. Miguel Bang's no. 81, of the John Donnell Smith collection, combines these two characters in one plant. Both of the Philippi specimens are from the Province of Tarapaca in the extreme northern part of Chile. South American material is very scanty in North American herbaria, and it may be that when more of it becomes available a still closer relation will be shown between this and *B. procumbens*.

HERBARIUM SPECIMENS.

SOUTH AMERICA: *Fries* 1058a, Bolivia; 813, Argentine. *Bang* 81, Bolivia. *Philippi*, 267 and 208, Chile. *Rusby* 34, Bolivia. *Stuckert*, Herb. Argent. 17700.

3. *Bouteloua stolonifera* Scribn.

Bouteloua stolonifera Scribn. Proc. Acad. Phila. 1891: 302. 1891. The type is *Pringle* 3174, in the U. S. National Herbarium, from Honda Station, Zacatecas, Mexico, August 19, 1890.

DESCRIPTION.

A densely tufted, strongly stoloniferous, low, smooth perennial; sheaths short, indistinctly striate; blades flat, narrow, 3 to 5 cm. long, with involute edges, minutely scabrous under a lens, abundant and mostly radical; spikes solitary upon short, erect or ascending culms, 5 to 10 cm. high, recurved into a circle when mature, 2 to 2.5 cm. long; spikelets lax, 15 to 20, pectinate, about 15 mm. long including awns; glumes lanceolate, acuminate, the first 5 and the second 8 mm. long, smooth or minutely hispidulous on the keel; lemma smooth, 8 to 10 mm. long, including 3 long, unequal, hispid awns, the central 1 to 2 mm. longer than the lateral; palea about 5 mm. long, narrow, with involute margins, the 2 awns about 1 mm. long; rudiment consisting of 2 or 3 aborted florets in the shape of 5 to 8 or more long, hispid awns and 3 to 5 small scales upon a short stipe about 1 mm. in length; caryopsis not seen. (FIGURE 30.)

When not headed out this species resembles somewhat the female plants of *Bulbilis dactyloides*. It often grows thick enough in shallow depressions in the mesas to make a semblance of a turf. Extensive areas of it have not been seen.

HERBARIUM SPECIMENS.

MEXICO: *Lloyd* 104, Cedros, Zacatecas. *Schaffner* 1879, San Luis Potosí. *Pringle* 3174, La Honda Station, Zacatecas.

4. *Bouteloua scorpioides* Lag.

Bouteloua scorpioides Lag. Gen. & Sp. Nov. 5. 1816. This species is identified on no other evidence than the brief description, "Culmo erecto filiformi monostachyo: spica lineari-oblonga spiraliter revoluta," and the additional information that the plant is from "N. Hisp." and perennial. Fournier referred this to *Chondrosium tenue* H. B. K., to which it is closely allied, the difference between them consisting chiefly in the perennial character of *Bouteloua scorpioides*. Fournier does not appear to have seen this species at all and consequently it was perfectly natural for him to refer this name to the annual *C. tenue*, which it so closely resembles.

Actinochloa? scorpioides Roem. & Schult. Syst. Veg. 2: 420. 1817. Based upon *Bouteloua scorpioides* Lag.

Atheropogon scorpioides Spreng. Syst. Veg. 1: 293. 1825. Based upon *Bouteloua scorpioides* Lag.

Chondrosium? scorpioides Kunth, Rév. Gram. 1: 94. 1829. Based upon *Bouteloua scorpioides* Lag.

DESCRIPTION.

A smooth, cespitose, half-prostrate or spreading perennial; culms ascending, seldom geniculate or branched, 20 to 30 cm. long; sheaths striate, smooth, close; blades narrow, involute, short, only 4 or 5 cm. long, with a narrow ligular fringe of white hairs; spike always solitary and terminal, 4 to 5 cm. long, revolute toward maturity; spikelets 50 to 70, pectinate, about 6 mm.



FIG. 31.—*Bouteloua scorpioides*. a, Spikelet; b, c, lemma and palea of first floret; d, e, rudimentary lemma and palea of second floret; f, rudiment of third floret. a, Scale 5; b-f, scale 7.5. From Pringle 8820.

ma, truncate, awnless; rudiment 5.5 mm. long, hairy-tufted, with 3 equal scabrous awns and 2 axillary scales representing the lobes of the lemma; caryopsis not seen. (FIGURES 31, 32.)

This species is as uniformly 1-spiked as is *B. procumbens*. In other respects the herbarium material bears a close similarity to some single-spiked forms of *B. gracilis*. On the whole, however, the plants as well as the glumes are smoother and the spikes are longer, heavier, and more revolute. In the field the difference is still more striking. In this species the larger plants grow in more conspicuous bunches and are more spreading, and the general aspect, owing to this fact and the lack of pubescence, is entirely different. One-spiked forms of *B. gracilis* are not at all uncommon. Such

forms might easily be confused with *B. scorpioides* by one who had never seen the latter in the field. The range of *B. scorpioides*, however, is apparently limited to the high plateau of central Mexico. One-spiked forms that have been examined from northern Mexico or the United States can not be referred to this species.

When Pringle's no. 8820, from Zontecomate Station, Hidalgo, Mexico, was first seen it was thought that it was a distinct species. Pittier's no. 422, from the State of

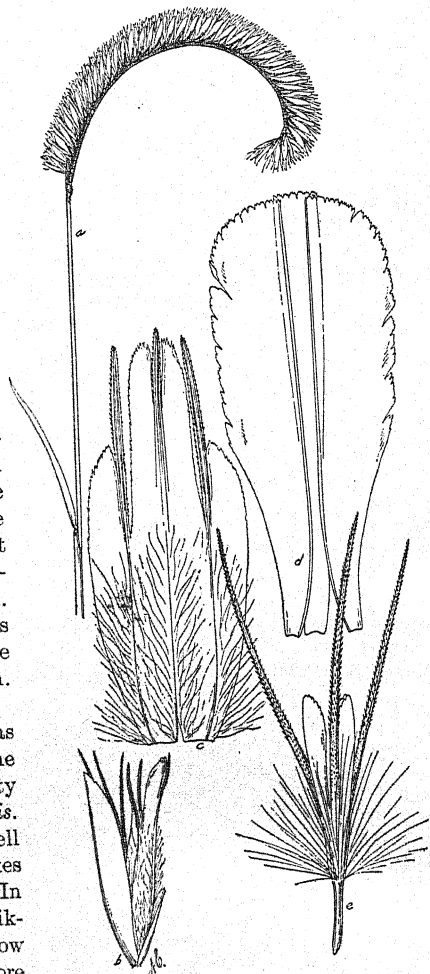


FIG. 32.—*Bouteloua scorpioides*. a, Spike; b, spikelet; c, d, lemma and palea of first floret; e, rudiment. a, Scale 1; b, scale 5; c-e, scale 10. From Griffiths 8527.

Puebla, and Lloyd 105, from Hacienda de la Cedros were placed with the Pringle collection. Later collections by myself, however, from the Valley of Mexico connect the small, narrow-leaved plants represented by Pringle 8820, with my large, comparatively wide-leaved plant from Encinillas. The species appears to vary from the large plant described above to a diminutive plant often not over 7 or 8 cm. high, having narrow, rather rigid, mostly radical leaves. The smaller forms resemble *B. procumbens* except that they are perennial, while the larger ones look more like single-spiked plants of *B. gracilis*.

The species has been collected at various places from northern Zacatecas to Orizaba and is especially abundant in the Valley of Mexico although not at all common in collections. Doubtless the common form of the Valley of Mexico may be found included with *B. procumbens* in some herbaria.

5. *Bouteloua hirticulmis* Scribn.

Bouteloua hirticulmis Scribn. U. S. Dept. Agr. Div. Agrost. Circ. 30 : 4. 1901. The type is T. S. Brandegee's no. 11, collected September 29, 1899, at Sierra de San Francisquito, Lower California.

DESCRIPTION.

A caespitose, erect, stout perennial, about 60 cm. high; culms simple, densely hirsute-pubescent below but naked above; sheaths short, striate, glabrous or with a few scattered hairs; ligule conspicuously ciliate-hairy; blades 10 to 20 cm. long, flat, minutely scabrous, tubercular-hairy near base; spikes 2 or 3, apparently normally 2, about 5 cm. long, upon short, curved, woolly peduncles, the rachis projecting 1 to 2 cm. beyond the distal spikelets; spikelets pectinate, numerous, 50 to 60, about 6 mm. long; glumes lanceolate, subulate-pointed, pubescent, the first 2.5 to 3 mm. long, the second 5 to

5.5 mm. long, the latter bearing upon the dorsal surface long papillose hairs, 1 to 3 mm. in length, much like those of *B. hirsuta*; lemma 3-lobed, with short awns from the 3 nerves, the central lobe 1 to 1.5 mm. longer than the lateral pair, hairy, especially on the nerves; palet 2-nerved, awnless, glabrous, narrowly ovate, 4 to 5 mm. long; rudiment consisting of 3 scabrous awns, 3 to 4 mm. long, expanded and scale-like below, the central slightly the longest, interspersed with 2 or 3 scales on a naked stipe 1 to 1.5 mm. long, bearing a few hairs at its apex; caryopsis not known. (FIGURE 33.)

This can be looked upon as a robust, hirsute, hairy-culmed form of *B. hirsuta*. Its tuberculate-hairy second glume and woolly culms are its distinguishing characteristics.

Palmer's no. 201, and Nelson's no. 1259 are typical. Nelson's no. 3121 (Roadside between Tuxtla and San Cristobal, Chiapas, Mexico, September, 1895, in U. S. National Herbarium) includes *B. hirsuta* and *B. hirticulmis* mounted on the same sheet, indicating that the collector considered them the same species and probably

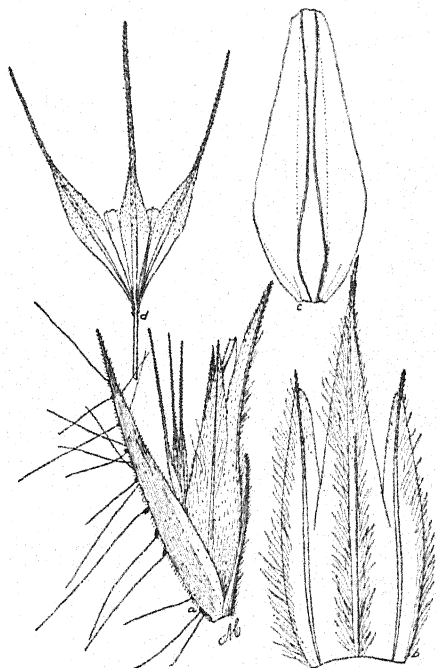


FIG. 33.—*Bouteloua hirticulmis*. a, Spikelet; b, c, lemma and palet of first floret; d, rudiment. a, Scale 7.5; b-d, scale 10. From type specimen.

found them growing intermixed. This still further goes to prove the close relationship of the two species and really throws a doubt upon the validity of *B. hirticulmis*. My own collection from western Jalisco illustrates the same close relationship. Indeed, frequent gradations may be found between this and *B. hirsuta* in the mountains northwest of Guadalajara. In the vicinity of Aguascalientes the species has less hairy culms, as shown by some of my own distributions. Further collections from the Pacific coast of Mexico, from Lower California to the Isthmus are necessary.

HERBARIUM SPECIMENS.

MEXICO, Brandegee, El Tase, Lower California. Nelson 3121 (in part), Chiapas; 1259, Valley of Oaxaca. Palmer 201, Rio Blanco, Jalisco.

6. *Bouteloua hirsuta* Lag.

Bouteloua hirsuta Lag. Var. Cienc. 2⁴: 141. 1805. My interpretation of this is based upon the description and upon a specimen sent by Lagasca to Munich in 1820. A specimen in the herbarium of the Madrid Botanical Garden marked *B. hirsuta* in Lagasca's hand has both *B. hirsuta* and *B. gracilis* on the same sheet. This, however, is not the type, for that was burned in Lagasca's first herbarium. The spike of *B. hirsuta* from this specimen before me is very large and represents the largest of our southern forms of this species. The Munich and Madrid specimens appear to be from the same collection. See also U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 39. f. 1-3. 1890; Britt. & Brown, Illust. Fl. 1: 180. f. 411. 1896; U. S. Dept. Agr. Div. Agrost. 7: 223. f. 205. 1897.

Bouteloua hirta "H. R. M."^a Lag. Var. Cienc. 2⁴: 141. 1805. A garden name mentioned as a synonym of *Bouteloua hirsuta*; *B. hirta* Scribn.^b is based on *Chondrosium hirtum* H. B. K.

Chondrosium hirtum H. B. K. Nov. Gen. & Sp. 1: 176. pl. 59. 1816. The plate identifies this without doubt, although the species normally bears 2 to 4 spikes, not one spike as figured and described.

Actinochloa hirsuta Roem. & Schult. Syst. Veg. 2: 419. 1817. Based upon *Bouteloua hirsuta* Lag.

Eutriana hirta Trin. Gram. Unifl. 240. 1824. Based upon *Actinochloa hirsuta* Roem. & Schult.

Atheropogon hirtus Spreng. Syst. Veg. 1: 293. 1825. Based upon *Chondrosium hirtum* H. B. K.

Chondrosium hirsutum Sweet, Hort. Brit. 1: 455. 1826. A name only.

Atheropogon papillosus Engelm. Amer. Journ. Sci. 46: 104. 1843. The description is sufficient to identify this. The type, in the Engelmann Herbarium, is Geyer's specimen collected near Beardstown, Illinois, in 1842. A specimen so named corresponding to this description in the Gray Herbarium further identifies it. This is mounted on the same sheet as Mead's specimen from Mason County, Illinois, collected August 25, 1845.

Chondrosium aschenbornianum Nees, Linnaea 19: 692. 1847. The type is Aschenborn Exsic. no. 331. The specimen of this in Willdenow's herbarium is *Bouteloua hirsuta*. Fournier has listed many numbers from Mexican collectors under this name but all others examined from whatever source are *B. gracilis*. As an illustration of the mix up, my notes on Bourgeau's no. 448 are interesting. In the National Herbarium *B. gracilis* and *B. hirsuta* are found under this number on the same sheet. In the Gray Herbarium, and the herbaria at Paris and at the St. Petersburg Botanical Garden, this number is *B. gracilis*, while a duplicate of the type in the Willdenow Herbarium is *B. hirsuta*.

^a I. e., Hortus Regius Matritensis.

^b Contr. Nat. Herb. 2: 531. 1894.

Chondrosium foenum Torr. in Emory, Mil. Recon. 154. pl. 12. 1848. The plate is sufficient to identify this.

Chondrosium papillosum Torr. in Marey, Expl. Red. Riv. 300. 1852. Based upon *Atheropogon papillosus* Engelm.

Bouteloua foena Torr. Cat. Pl. Surv. W. 100th Merid. 18. 1874. Based upon *Chondrosium foenum* Torr.

Chondrosium drummondii Fourn. Mex. Pl. 2: 137. 1881. The type number (*Drummond* 323) in the herbarium of the Muséum at Paris and in the herbarium of the St. Petersburg Botanical Garden belong to this species, but the prolongation of the rachis is rather short in the fragments before me from both the above depositories. A photograph of the type taken for me by A. S. Hitchcock in 1907 represents the typical form of the species.

Bouteloua aschenborniana Griseb.; Fourn. Mex. Pl. 2: 137. 1881. A manuscript name mentioned as a synonym of *Chondrosium aschenbornianum* Nees.

Bouteloua palmeri Vasey, Bull. Torrey Club 14: 9. 1887. A name only. Vasey observes that this species, which was distributed to some extent under this name, is a variety of *B. hirsuta*.

Bouteloua hirsuta minor Vasey, U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 39. f. 2. 1890. See *B. hirsuta major*. The type of this variety appears to be a specimen collected in Texas, 1883, by S. B. Buckley.

Bouteloua hirsuta major Vasey, U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 39. f. 3. 1891. The specimen in the National Herbarium locates Vasey's work without doubt, although the label is not in Vasey's writing.

Bouteloua hirsuta palmeri Vasey; Beal, Grasses N. Amer. 2: 417. 1896. Vasey says^a that this has been distributed as *B. palmeri*, but he refers it to *B. hirsuta*. The specimen in the National Herbarium plainly marked by Vasey "Cultivated from seed collected by Palmer in Mexico, 1886," fixes the type without any question. Watson^b also uses this name.

Bouteloua bolanderi Vasey; Beal, Grasses N. Amer. 2: 417. 1896. Beal mentions this as a synonym under *B. hirsuta* variety *palmeri*. It is said to have been cultivated from seed collected by Palmer in Mexico in 1886. I have not been able to find in the National Herbarium any specimen marked *B. bolanderi*.

Bouteloua hirta Scribn. Contr. Nat. Herb. 2: 531. 1894. Based on *Chondrosium hirtum* H. B. K.

Bouteloua hirta major Vasey, Contr. Nat. Herb. 2: 531. 1894.

Bouteloua hirta minor Vasey, Contr. Nat. Herb. 2: 531. 1894.

DESCRIPTION.

A caespitose, rigid, erect perennial of very variable habit, size, and general appearance, in the northern portion of the Great Plains forming a sod, but in the Southwest and in Mexico growing in isolated clumps, rather rigid and stout, with unbranched culms, smooth, striate, close sheaths, small, ciliate ligule, and flat, somewhat hispid, narrow blades, more numerous below than above; panicle racemose, 3 to 5 cm. long, bearing 1 to 4 spikes, normally 2 in the north but more commonly 3 or 4 in the south, 2.5 to 3.5 cm. long, with a projection of the rachis 5 to 8 mm. beyond the last spikelets; spikelets numerous, 35 to 45, pectinate, consisting of a lower, fertile floret and an upper rudiment, glumes unequal, the first minutely hispid, about 3 mm. long, acuminate, the second acuminate, short-awned, about 6 mm. long, minutely hispid and conspicuously tuberculate-hairy; lemma 3-toothed, the central tooth terminating in a short, hispid awn slightly longer than the lateral teeth, these simply acuminate-pointed, conspicuously pubescent; palea oval, broadly pointed; rudiment consisting of 3 hispid, equal awns, about 6 mm. long, and one or two small scales upon a stipe, 1 to 2 mm.

^a Bull. Torrey Club 14: 9. 1887.

^b Proc. Amer. Acad. 22: 461. 1887.

long, the latter slightly pubescent above; caryopsis about 1.5 to 2 mm. long, 0.5 mm. wide, oval, more or less pointed at both ends, the scutellum covering nearly the entire ventral surface and the embryo extending nearly to the apex. (FIGURE 34.)

The distribution of this species is very wide, from British Columbia southward through the continental highland and again at points along the Gulf coast in Florida. As in the case of *B. gracilis* the northern and southern forms differ widely in both habit and general aspect, the northern being shorter as a rule and showing a tendency to form a sod, while the southern is in the strictest sense a bunch grass. It reaches its best development upon stable, sandy-loam soils and extends in New Mexico and Arizona into the upper foothills. The most abundant development that has been met

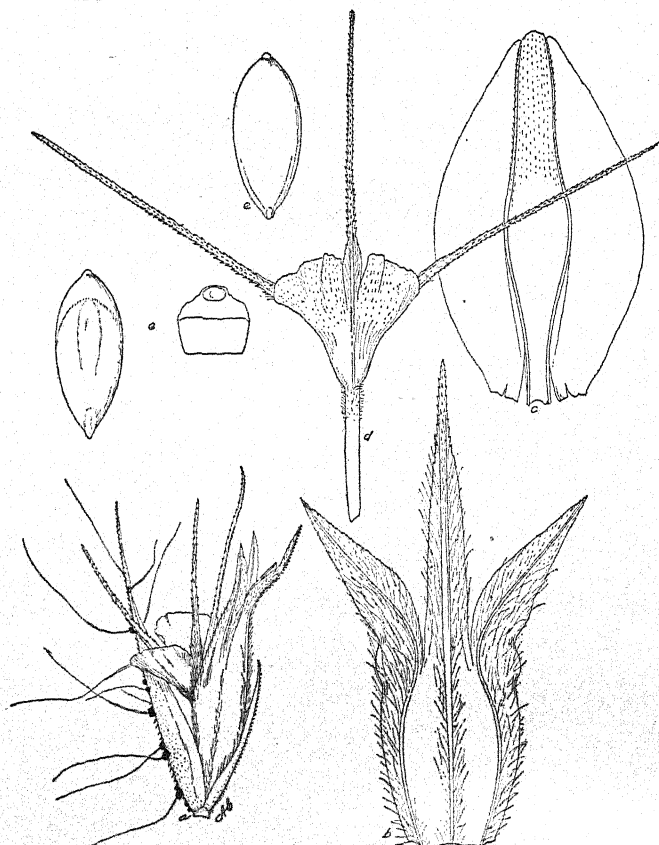


FIG. 34.—*Bouteloua hirsuta*. a, Spikelet; b, c, lemma and palea of first floret; d, rudiment; e, two views and cross section of caryopsis. a, Scale 7.5; b-e, scale 12.5. From Griffiths 6125.

with is in the sandy lands of the Texas-New Mexico line east of Roswell and in foothills from Arizona south. In the former situation this and two or three species of *Andropogon* constitute about the only forage. It also grows almost to the exclusion of all else in localities upon the plateau of central Mexico.

The species is well understood and seldom incorrectly named in collections. Its distinguishing characteristics are the prolongation of the rachis beyond the spikelets, the tuberculate, hairy glumes, and the more or less papillose-hairy leaf margins. Heller 1878, Lemmon 3175 and 4673, Pringle 409, and Palmer 1357 are typical. Clements's no. 1 (Manitou, Colorado) and Rydberg's no. 1552 are 1-spiked forms which are common enough, but not so commonly collected.

HERBARIUM SPECIMENS.

- ARIZONA: Jones 540, Bowie. Lemmon 4639, 4637, and 4640, S. E. Arizona; 3175. Sulphur Spring Valley. MacDougal 616, Beaver Creek. Toumey 26, Prescott, Griffiths 1865, Dragon Mountains; 1948, Pearce; 1809, Rincon Mountains; 3375 and 3371, Santa Rita Mountains. Griffiths & Thorner 26 and 222, Santa Rita Mountains. Hitchcock 3700, Patagonia; 3732, Benson.
- COLORADO: Williams 2117, Colorado Springs. Rydberg 2360, Meadow Park. Hitchcock 2270, Ouray.
- FLORIDA: Simpson (December, 1891). Garber (November, 1878). Combs & Baker 1105, Orange County. Baker 33, Orange County.
- ILLINOIS: Patterson 590, Oquawka. Wilcox 58, on Mississippi River; 41, Aurora; 63, Manito. Gleason 1003, Havana.
- IOWA: Ball 116, Ames.
- KANSAS: Smyth 78, Greensburg. Shear 147 and 702, Osborne. Norton 908, Riley County. Thompson 125, Syracuse.
- MISSOURI: Bush 389a, Atchison County.
- NEBRASKA: Rydberg 1552, near Mullen. Morris 434a. Williams 3008, Weeping Water. Clements 2738, Pishelville. Elmer 133, Crete.
- NEW MEXICO: Wooton 419 and 1098, Organ Mountains. Vasey 101, Organ Mountains. Metcalfe 754, Bear Mountains. Plank 19, Socorro. Greene 403, Silver City. Hitchcock 3790, Organ Mountains. Standley 4977, San Miguel County. Fendler 951 of 1847.
- SOUTH DAKOTA: Thorner 242, Sioux Falls. Rydberg 1135, Hot Springs.
- TEXAS: Riggs 66, Marshall. Lindheimer 731 (Fasc. IV). Jermy 781, Gillespie County. Nealley 353 and 93, Santa Ana. Letterman, San Antonio (1882). Buckley (1881). Heller 1878, Kerrville. Reverchon 4216 and 1153, Dallas; 4, Comanche Peak; 4089, Wood County. Bailey 740, Guadalupe Mountains; 393, Chisas Mountains. Tracy 8205, Dallas; 8221, Colorado; 8213, Weatherford; 8214, Big Springs; 8205, Fort Worth. Ball 994 and 893, Chillicothe.
- MEXICO: Conzatti 2013, State of Oaxaca. Schaffner 1018, San Luis Potosí; 158, Valley of Mexico. Pringle 409, Chihuahua; 11215, Tula. Wilkinson 347, Santa Eulalia Mountains. Brandegee 25, Cape Region, Lower California; 11, Sierra de Laguna, Lower California. Palmer 405, Saltillo; 807, Durango. Parry & Palmer 943, San Luis Potosí. Nelson 6246, Pacheco, Chihuahua. Rose 1904 and 3293, Territory of Tepic; 2588, State of Jalisco.

7. *Bouteloua gracilis* (H. B. K.) Lag.

Actinochloa ciliata Willd.; Beauv. Ess. Agrost. 41. 1812. (See *Chondrosium ciliatum*.)

Chondrosium ciliatum Willd.; Beauv. Ess. Agrost. 158. 1812. Beauvois lists this name in the index, basing it upon the above manuscript name of Willdenow. In Beauvois's personal copy of his Essai,^a he has written in the index in his own hand that this is *C. gracile* H. B. K.

Chondrosium gracile H. B. K. Nov. Gen. & Sp. 1: 176. pl. 58. 1816. The cited plate and description, together with a specimen in Willdenow's herbarium, "ex herb. Humboldt ex herb. Kunth" leave no doubt in my mind that this is what in this country we have long called *B. oligostachya*. It is true that Kunth figures a single-spiked plant, which is the uncommon form. It is rather curious that Humboldt and Bonpland did not collect the more common form, but not nearly so curious as it would have been if they had not collected this widely distributed species at all. Kunth also figures a single-spiked form of *B. hirsuta*, though this is the less common form of that species.

^a This copy is now in the library of the U. S. Department of Agriculture.

Actinochloa gracilis Willd.; Roem. & Schult. Syst. Veg. 2: 418. 1817. Based upon *Chondrosium gracile* H. B. K.

Atheropogon oligostachyum Nutt. Gen. Pl. 1: 78. 1818.

Eutriana gracilis Trin. Gram. Unif. 240. 1824. Based upon *Actinochloa gracilis* Willd.

Atheropogon gracilis Spreng. Syst. Veg. 1: 293. 1825. Based upon *Chondrosium gracile* H. B. K.

Eutriana? oligostachya Kunth, Rév. Gram. 1: 96. 1829. Based upon *Atheropogon oligostachyus* Nutt.

Bouteloua gracilis Lag.; Steud. Nom. Bot. ed. 2. 1: 219. 1840. Based upon *Chondrosium gracile* H. B. K.

Chondrosium oligostachyum Torr. in Marcy, Expl. Red Riv. 300. 1852. Based upon *Atheropogon oligostachyum* Nutt.

Bouteloua oligostachya Torr.; A. Gray, Man. ed. 2. 553. 1856; see also U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 41. 1890; Britt. & Brown, Illustr. Fl. 1: 180. f. 4. 1896; U. S. Dept. Agr. Div. Agrost. Bull. 7: 222. f. 204. 1897 and op. cit. 20: 106. f. 80. 1900.

Bouteloua oligostachya intermedia Vasey, Grasses U. S. 33. 1883. A name only. No specimen so marked can be found in the National Herbarium.

Bouteloua oligostachya? major Vasey, Descr. Cat. Grasses U. S. 62. 1885; Dewey, Contr. Nat. Herb. 2: 531. 1894; Beal, Grasses N. Amer. 2: 418. 1896.

Bouteloua major Vasey, Bull. Torrey Club 14: 9. 1887. Vasey publishes a name only and refers to specimens previously distributed under it. He also states that this is a variety of *B. oligostachya*. The type is a specimen cultivated from seed collected by Palmer in Chihuahua, Mexico, in 1886.

Bouteloua stricta Vasey, Bull. Torrey Club 15: 49. 1888. A very brief description is given; a fuller description is furnished later.^a The type is C. G. Nealley, without number, western Texas, 1887. The species commonly assumes in the southwest the form represented by Vasey's type.

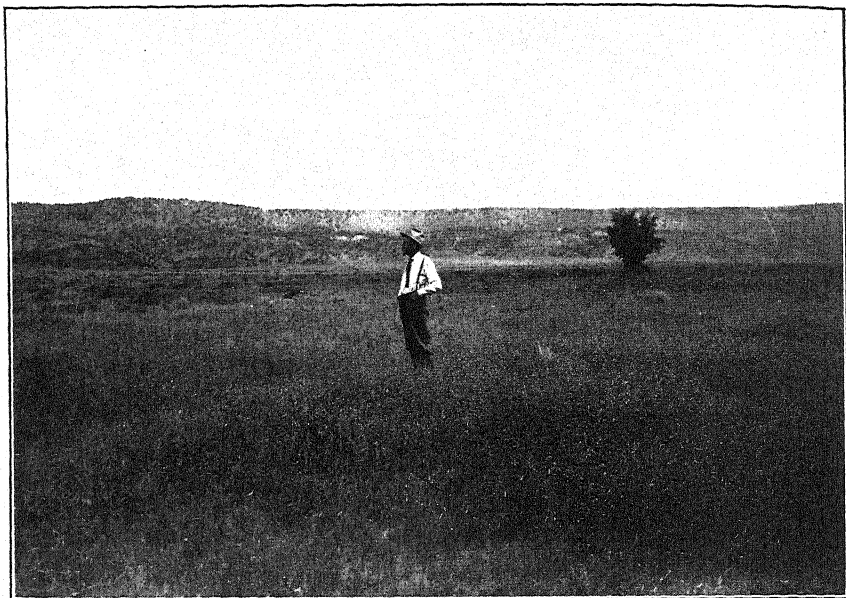
Bouteloua oligostachya pallida Scribn.; Beal, Grasses N. Amer. 2: 418. 1896. Pringle 407 is the duplicate type in the National Herbarium. There appears to be no good reason for recognizing such a variety. Pallid and dark-colored forms may be found in nearly all species of the genus.

DESCRIPTION.

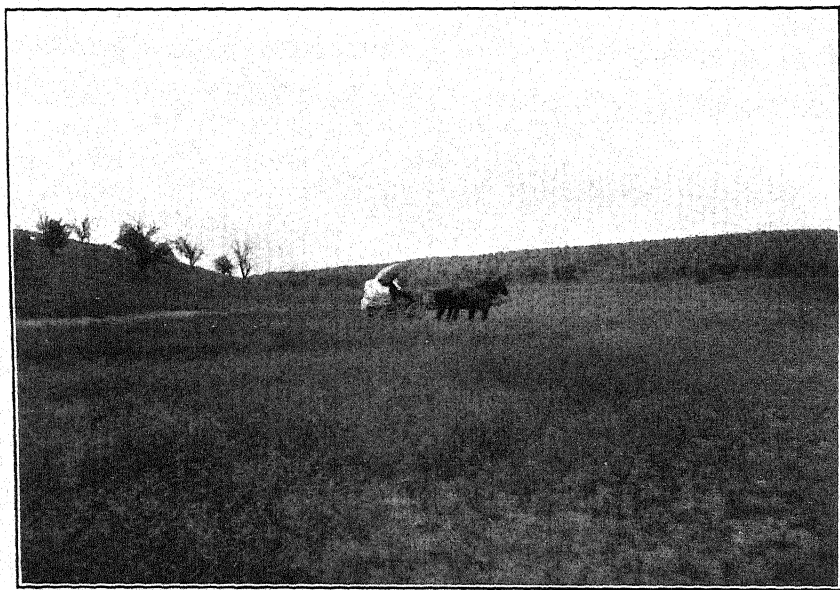
A stout, erect, smooth, caespitose perennial, forming a rough sod in the north, but usually in isolated tufts in the south and much larger and ranker in growth; culms branched only at the very base if at all, sheaths loose, striate, smooth; ligule reduced to a line with at most only a few scattered hairs; blades linear, rather abundant, about 5 to 10 cm. long, 1 to 2 mm. wide, flat, minutely scabrous-margined; spikes normally 2, often 1 or 3 or 4, seldom 5 or 6, very variable in length, commonly above 3 cm.,^b more or less recurved in age with no projecting sterile rachis; spikelets pectinate, on short, minutely pubescent pedicels, numerous, often as many as 80, consisting of a fertile flower and a rudiment; glumes lanceolate, short-awned, keeled, minutely scabrous, the lower 3 to 3.5 mm. long, the upper 5 to 6 mm. long; lemma about 6 mm. long, pubescent, 3-awned, the central awn slightly longer, all hirsute; palea about 5 mm. long, shortly 2-awned from the nerves, the latter slightly hirsute above; rudiment consisting of 3 scabrous, nearly equal awns with 2 or 3 scales at their bases all supported on a short stipe, 1 to 1.3 mm. long, hairy-tufted at base and apex; caryopsis 2.5 to 3 mm. long, 0.5 mm. wide, concave on the dorsal and sharply convex

^a U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 45. 1890.

^b One specimen without data from Thurber's herbarium in Herb. Mo. Bot. Gard. has spikes 9 cm. long.



A. LARGE NATIVE CROP OF *BOUTELOUA GRACILIS* (H. B. K.) LAG.



B. *BOUTELOUA GRACILIS* ON THE MEXICAN BORDER OF ARIZONA.

on the ventral surface, the scutellum covering over three-fourths of the ventral surface. (PLATE 72, A, B. FIGURE 35.)

This is without doubt the most important economic species of the genus, extending from Manitoba to South America. It is doubtfully reported from Tampa, Florida. As would be expected from a plant of such wide range, it is extremely variable. The above description is drawn in the main from my no. 6108 from the Sonoyta Valley of Arizona, which is very different from the plains region form. The latter produces a rough, rather bunchy sod and sends up but few culms, the abundant basal leaves forming a curly covering close to the ground, the species on this account often being confused in the popular mind with the buffalo grass (*Bulbils dactyloides*). But in the southern desert region where, along the Mexican border, it grows in abundance at an altitude of about 5,000 feet it is usually in isolated large bunches. In favorable situations in swales such as are found on the eastern slope of the Santa Rita Mountains of Arizona it assumes more nearly the appearance of the northern form so far as habit is concerned (Pl. 72, B). In the South the plants usually grow much larger. It is

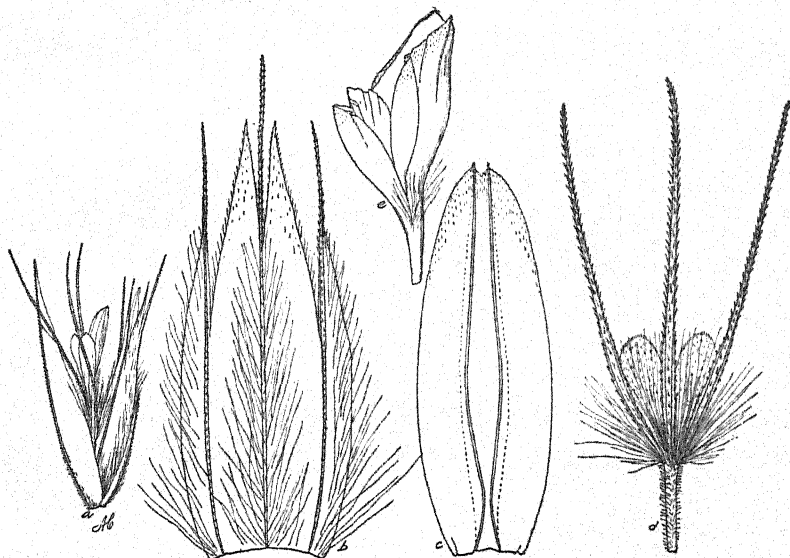


FIG. 35.—*Bouteloua gracilis*. a, Spikelet; b, c, lemma and palea of first floret; d, e, rudiments of second and third florets. a, Scale 7.5; b-e, scale 15. From type specimen of *B. stricta*.

not at all uncommon to find plants there 60 or 70 cm. high, while upon the prairies of the Dakotas the species seldom grows over half as high.

The difference in habit has been assumed by some to indicate a different species, but after studying the species from North Dakota to Oaxaca and cultivating it several times I am not able to take this view. It must be considered that the prairie form of the Dakotas and Montana occurs not only upon the cold, high prairies of the north, but upon the high tableland of northeastern New Mexico (Pl. 72, A), upon the San Francisco highland of northern Arizona, upon the Santa Rita highland of southern Arizona, and in many isolated localities in highland Mexico. This low turf-forming form passes by imperceptible gradations into the tall, robust, strictly bunchy form represented best by the type of *B. stricta*.

EXPLANATION OF PLATE 72.—A. A growth of *Bouteloua gracilis* under plains conditions in northeastern New Mexico. For several years this locality has been grazed during the winter months only. B. A turf of *Bouteloua gracilis* at an altitude of 5,000 to 6,000 feet. Compare with figure A. This species does not form a turf thus far south, except at a considerable altitude and under favorable soil and moisture conditions.

Again, when the northern turf-forming and the southern bunched form are grown together their habits are more alike. Both will form a turf under proper moisture conditions, and both when cultivated become tall and rank, similar to *B. stricta* (Pl. 69, B).

In the publications of the United States Department of Agriculture this species is usually referred to as "blue grama." The Spaniards of our southwest as well as of Mexico refer to it simply as "grama," which they do not distinguish from similar species.

One of the most valuable characteristics of this species, as well as of some others of the genus, is the short period of development. It is a 60 to 80 day grass. Upon the Dakota prairies it produces fresh feed in late May and matures during the drought of August. In southern Arizona and the highlands of Mexico it starts to grow about the middle of July and matures with the close of the rainy and cooler season of late September and early October. It grows in regions where it is cured by drought, and not by frosts, the effect being a dead herbage which retains much of its nutriment, making good dry grazing during the winter season, the value of the grass being proportionate to the dryness of the season. A rain after it has cured much reduces its value.

Shear's no. 813, Knowlton 140 and 141, Rydberg 3429, Williams 2143, Nelson 8307, Merrill & Wilcox 447, Ward 47, and Griffiths 40 are typical of the prairie and northern Rocky Mountain region. In unsodded regions from Colorado southward except at higher elevations, it assumes more of the characters exhibited by specimens collected by Wilcox at Fort Huachuca, in 1884, Mearns 2301, Metcalfe 698, Pringle 407, and Townsend & Baker 257. Parish Brothers 1528, Herb. Colo. State Agr. College 3534 (distributed by N. Y. Bot. Gard.), Skehan 64, and Nealley from Texas, in 1887, are mostly 1-spiked forms, and such forms occur throughout the range of the species. They are to be looked upon as dwarfs. They appear to be very common in the lower Sierras in California, at least they have been collected there a number of times.

There is a very peculiar form of the species in the extreme western portion of northern Texas. It differs from the common form mainly in its hairiness, but it occurs in perfectly circumscribed patches among the other form and can be readily distinguished at some distance. It has been seen twice north of Tuxline, but has never been collected and has not been detected in any of the collections examined. So far as hairiness is concerned, however, it is almost perfectly matched by a collection by Lindheimer (Herb. Texicana Exsic. no. 731) in the herbarium of the Missouri Botanical Garden. This, however, is the large, robust, southern form which differs in general appearance from the inhabitant of the plains.

HERBARIUM SPECIMENS.

ARIZONA: Blumer 1704, Chiricahua. Hitchcock 3656, Patagonia. Chase 5834, Flagstaff. Hough 12, Moki Reservation and Little Colorado River. Leiberg 5927, San Francisco Forest Reserve. Griffiths 3369 and 3370, Santa Rita Forest Reserve; 1863, Dragoon Mountains; 1552, Tucson; 1980, Pearce; 1905, Wilcox; 6108, Fort Crittenden. MacDougal 299, Flagstaff. Mearns 923, Bisbee; 1127, San Pedro River; 2301, White Water; 2090, San Luis Mountains. Jones 4240, Bowie. Lemmon 4641, 4642; northern Arizona, 427, 428. Towney, Chiricahua Mountains; 20, Santa Catalina Mountains. Wilcox, Fort Huachuca. Griffiths & Thorner 225, Santa Rita Mountains; 264, Empire Ranch.

CALIFORNIA: Hall 7589, Santa Ana Canyon. Wilder 744, San Bernardino Mountains. Grinnell 354, San Bernardino Mountains. Abrams 2100, San Bernardino County. Parish Brothers 1528, Bear Valley, San Bernardino Mountains. Lemmon 5445.

COLORADO: Chase 5303, Manitou; 5290, Pikes Peak Region; 5393 and 5403, Harbert Ranch, Las Animas County; 5346, near Starkville. Tidestrom 65a, Hugo. Shear

- 858, Alamosa; 813, Huerfano County; 7491, Colorado Springs; 978, Canyon City; 776, Walsenburg; 642, Georgetown. *Williams* 2143, Floreasant; 2127, Colorado Springs. *Wolfe* 1112, 1113, 1114, Twin Lakes. *Baker, Earle & Tracy* 971, Durango. *Shear & Bessey* 1419, Yampa. *Hitchcock* 1728, Pikes Peak; 1701, Garden of Gods. *Snow* 31a, Estes Park. *Vasey*, Fort Garland, 1884. *Griffiths* 3303, Rocky Ford. *Holm* 584, Gunnison.
- KANSAS: *Hitchcock* 3834, Manhattan. *Shear* 705 and 153, Osborne. *Thompson* 53, Ulysses; 126, Linville; 31b, Ness County. *Norton* 909, Riley County.
- MINNESOTA: *Moyer* 23, Montevideo.
- MISSOURI: *Bush* 589, 489, Sheffield; 390a, Atchison.
- MONTANA: *Williams & Griffiths* 219, Billings. *Griffiths & Lange* 310, Chateau; 297, Du Puyer; 231, Mission Holy Family. *Rydberg* 3429, Judith River; 2179 and 2290, Manhattan. *Scribner* 377, Teton River; 2104, Melrose. *Williams* 305, Great Falls. *Shear* 409, Manhattan; 351, Melrose.
- NEBRASKA: *Rydberg* 1574, Plummer Ford; 2012, Central City; 1803, Hooker County. *Clements* 2737, Pishelville.
- NEW MEXICO: *Wooton & Standley* 3524, White Mountains. *Hitchcock* 3781, Organ Mountains. *Metcalfe* 1308, Kingston; 698, Bear Mountains. *Standley* 4404, Holy Ghost Creek; 4911, San Miguel County; 3524, White Mountains. *Fisher* 26, Torrence. *Wooton* 206, Lincoln County; 2962, Kennedy; 1097, Organ Mountains. *Mearns* 2331, Dog Mountains; 2510, Animas Valley. *Tracy* 8199, Carlsbad. *Wright* 2023. *Fendler* 947, 948. *Skehan* 64, Gray. *A. A. & E. G. Heller* 3779, Santa Fe. *Earle* 64, Gray.
- NORTH DAKOTA: *Brannon* 104, Minot.
- OKLAHOMA: *Ward* 47, Carville. *Bush* 787, Sapulpa.
- SOUTH DAKOTA: *Wilcox* 2, Brookings. *Griffiths* 137 and 800, Aberdeen; 26, Pierre; 40 and 767, Pierre to Huron; 363, Bellfourche; 319, Bixby; 210, Redfield; 746a, near Willow Creek. *Wallace* 20, White River. *Rydberg* 1136, Hot Springs.
- TEXAS: *Bull* 996 and 894, Chillicothe. *Jermy*, Bexar County. *Hopkins*, Jeff Davis County. *Nealley* of 1887 (dwarf).
- UTAH: *Tidestrom* 2854, Beaver. *Garret* 2541, Fish Creek Canyon. *Ward* 419. *Jones* 5647, Thurber; 5972a, Marysville; 6002, Panguitch Lake; 5204, Cedar City. *Ward* 419 and 743, Rabbit Valley.
- WYOMING: *Chase* 5237, Sundance; 5259 and 5260, Fort McKinney. *Rose* 472, Clark. *Knowlton* 1404 and 141, Lance Creek. *Merrill & Wilcox* 447, Laramie. *A. Nelson* 8349, Cassa; 8447, New Castle; 8295, Torrington; 8307, Fort Laramie; 2677, Continental Valley; 7441, Albany County; 3619, 3658, and 3909, Laramie County. *E. Nelson* 438, Laramie River; 438, Albany County. *Griffiths* 972, Beulah; 507, Bear Lodge Mountains; 297, White Horse Camp; 698, New Castle; 526, Devils Tower; 501, Sundance. *Merrill* 2 and 3, Laramie. *Williams* 2588, Sundance.
- CANADA: *Macoun* 2155, Northwest Territory; 13057, Assiniboia; 13035, Manitoba; 30043, Winnipeg; 30045, Assiniboia. *Hitchcock* 4979, Calgary; 4952, Alberta. *Macoun & Herriot* 72934, Saskatchewan; 72935, Alberta.
- MEXICO: *Pringle* 407, Chihuahua. *Schaffner* 132, San Luis Potosí; 1015, San Rafael. *Wilkinson* 63, Santa Eulalia Plains, Chihuahua. *Schumann* 1723, Parral. *Palmer* 24, Chihuahua; 545, Durango; 403 and 399, Saltillo. *Bourgeau* 448, Santa Fe. *Townsend & Baker* 257, Colonia Garcia. *Mearns* 1658, San José Mountains. *Parry & Palmer* 944, San Luis Potosí. *Lloyd* 242, Pico de Tierra, Zacatecas. *Nelson* 6330, Casas Grandes, Chihuahua. *Rose & Painter* 6710, Hidalgo.

8. *Bouteloua breviseta* Vasey.

Bouteloua breviseta Vasey, Contr. Nat. Herb. 1: 58. 1890. The type is C. G. Nealley's no. 669, from Screw Bean, Presidio County, Texas, September, 1889. See also U. S. Dept. Agr. Div. Agrost. Bull. 7: 219. f. 201. 1897.

DESCRIPTION.

A stout, rigid, erect perennial, 25 to 40 cm. high, with branching, perennial culms, the internodes, when protected, covered with a thick, scaly bloom, cespitose, spreading by short, stout, scaly rootstocks; sheaths rather close, striate, covering nearly the entire internode; ligule sparingly ciliate-hairy; blades small, 3 to 6 cm. long, convolute, narrow, rigid, acuminate-pointed, bearing a few scattered hairs on the upper surface; spikes normally 2, often 1 and less frequently 3, linear-oblong, 2 to 2.5 cm. long, straight or slightly recurved; spikelets numerous, 30 to 45, pectinately arranged, about 3 mm. long, consisting of a lower perfect floret and a rudiment, with often a very small second rudiment; first glume 2 to 2.5 mm., the second 3 to 3.5 mm. long, nearly smooth; lemma about 5 mm. long, having 4 teeth and 3 awns of nearly equal length, pubescent; palea smooth, awnless, rudiment about 4.5 mm. long, of 3 hispid awns of about equal length and a rudimentary scale, all arising from a tuft of long, white hairs at apex of a stipe. (FIGURE 36.)

This is a very interesting species, apparently confined to the calcareous soils of the Rio Grande Valley and its tributaries. It is one of the important grasses upon the

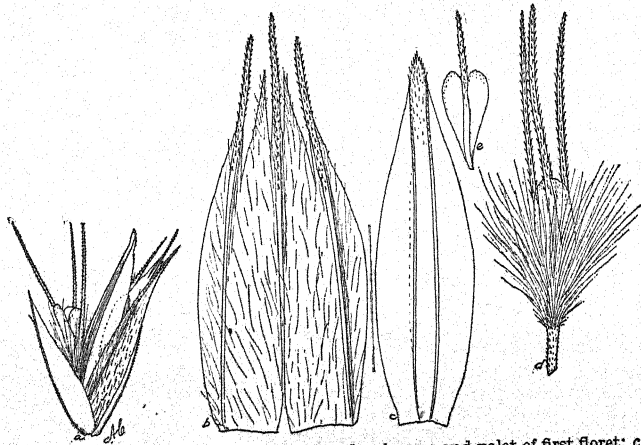


FIG. 36.—*Bouteloua breviseta*. a, Spikelet; b, c, lemma and palea of first floret; c, d, rudiments of second and third florets. a, Scale 7.5; b-d, scale 15. From *Nealley* 669.

white (gypsum) sands of southeastern New Mexico, where it often creeps into rather unstable earths. Good stands of the grass occur in the Pecos Valley upon soils containing 73.2 per cent calcium sulphate and 3.2 per cent calcium carbonate, according to the analysis of a sample collected in 1903 and submitted early in 1904 to the Bureau of Soils of the Department of Agriculture. In the Roswell district of New Mexico *B. breviseta* is very evidently confined to the gypsum deposits and is popularly known as "gyp" grass. It is a tough, wiry species, but is nevertheless utilized to a very large extent as a pasture grass. The amount of trampling which it endures is remarkable. The deposits of gypsum occur here between the water in and along the Pecos and the better grazing grounds upon the mesas beyond the bluffs. Because of this the trampling across this deposit is very heavy. The tenacious character of the grass is strikingly exhibited in the regions of heaviest traveling. Having perennial culms it is of particular service during a prolonged drought.

There are a number of specimens in the National Herbarium which correspond exactly with the type. *Havard*, western Texas, 1881; *Nealley* 785; *Wootton* 64 Otero County, New Mexico; and *Bailey* 340, Boquillas, Texas, are representative.

9. *Bouteloua ramosa* Scribn.

Bouteloua ramosa Scribn.; Vasey. U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 44. 1890. No specimen is cited in the original description. Beal^a cites Nealley's specimen from southwestern Texas. It is impossible now to locate the plant from which Vasey drew up the description. However, it is certain that it was a Nealley specimen, as Beal suggests. At any rate Vasey's figures leave no doubt as to the species, and there are several Nealley specimens of this species in the National Herbarium. See also U. S. Dept. Agr. Div. Agrost. Bull. 7: 218. f. 200. 1897.

Bouteloua oligostachya ramosa Scribn.; Beal, Grasses N. Amer. 2: 418. 1896. Reference is made by Beal to the U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 44. 1890, for this and *B. ramosa* (which see), but he cites Pringle 414 from Mexico under this variety. The same thing is referred to in each case and the inclusion of it in two places is evidently due to an oversight in editing. Palmer 1358 and Pringle 414 are also typical of the species.

The floral details of this species differ in no way from those of *B. breviseta*, but the habit is quite different. The culms, while of the same general half-perennial character and freely branched, are more spreading and invariably geniculate. The species grows on rough, stony, limy soils, from the lower Rio Grande region southward.

It is more than probable that further study will prove this to be really a form of *B. breviseta*, but there is not at the present time sufficient evidence available in collections to warrant making such a disposition formally.

HERBARIUM SPECIMENS.

TEXAS: Nealley 108, Presidio County; Chende Mountains; Presidio County; 108½, Sanderson, Pecos County. Bailey 340, Boquillas.

MEXICO: Pringle 414, Chihuahua. Wilkinson 346, Santa Eulalia Mountains. Palmer 1358, Monclora; 404, Saltillo. Rose & Painter 7729, Aguascalientes.

10. *Bouteloua parryi* (Fourn.).

Chondrosium parryi Fourn. Mex. Pl. 2: 150. 1881. Fournier cites as the type of this species Parry and Palmer 923½, but this is evidently a misprint for 943½.^b

Bouteloua polystachya vestita Wats. Proc. Amer. Acad. 18: 177. 1883. Palmer 1357 Sierra Madre, Nuevo León, Mexico, August, 1880, in the Gray, Herbarium, is the type. Parry and Palmer's no. 943½ cited by Watson is also in the National Herbarium.

Bouteloua vestita Scribn. in Dewey, Contr. Nat. Herb. 2: 531. 1894. Presumably based on *B. polystachya vestita* Wats. since Watson is cited in parentheses, but no synonyms are given. See also U. S. Dept. Agr. Div. Agrost. Bull. 7: 220. f. 202. 1897.

DESCRIPTION.

A woolly-pubescent, short-lived perennial, erect or reclining, the geniculate culms being simple or branched, cespitose or, when growing thickly, the individual culms scattering; sheaths loose, striate, pubescent, the ligule reduced to a ciliate-hairy line, with hairs a little more prominent than those on the edges of the sheaths; blades pubescent with long, scattered, minutely papillose hairs, 2 to 3 mm. long; spikes 4 to 8, usually 5 or 6, bilateral, but the black peduncle so curved as usually to make them appear unilateral, 2.5 to 3.5 cm. long; spikelets 40 to 65, pectinate, upon a slender, papillose-hairy rachis, consisting of a lower fertile floret and one or more upper rudiments; glumes keeled, the first smooth or sparingly pubescent at base, about 2 mm. long, with a short awn, the second woolly, with minutely papillose hairs, 3 or 4 mm. long, with minutely scabrous awn about 0.7 mm. long; lemma 3 to 4 mm. long,

^a Grasses N. Amer. 2: 416. 1896. ^b See Proc. Amer. Acad. 18: 177. 1883.

densely pubescent, 4-toothed, with 3 scabrous equal awns, about 2 mm. long; palet 4-toothed, 2-awned, pubescent on the edges only, about 2.5 mm. long; rudiment consisting of 3 scabrous, equal awns, about 4 mm. long, together with two or three small scales upon a stipe about 1 mm. long, bearing a tuft of long hairs at each end; caryopsis obovate, pointed at both ends, about 1.3 mm. long, less than 0.5 mm. wide, the scutellum covering nearly the entire ventral surface, the dorsal surface convex. (PLATE 73, A. FIGURE 37.)

The specimens cited in the original description are undersized and can scarcely be called caespitose. They differ, therefore, very decidedly from the large specimens of the Santa Rita Mountains. They also differ decidedly in color, my speci-

mens from southern Arizona being much lighter. Wooton's no. 6033 is especially dark colored, but this is easily accounted for by the abnormal rainfall of the season in which it was collected. The rains appeared very late that year and continued into the cool season. Grasses often show this excessive coloration when subjected to cooler nights than normal, either when growing later in season than usual or at high altitudes. The type specimens are so diminutive that they are really not at all representative of the species as it is commonly found. *Pringle* 413, *Nealley* 265, *Lemmon* 4638, well represent the common form of this species.

HERBARIUM SPECIMENS.

ARIZONA: *Mearns* 1121 $\frac{1}{2}$, San Pedro River, Mexican Boundary Line. *Nealley* 265, Oracle. *Lemmon* 426 and 4638, "S. E. Arizona." *Griffiths & Thorner* 206, Santa Rita Mountains. *Griffiths* 1819, 3415, Mescal.

NEW MEXICO: *Cockerell* 16, Jarilla Junction.

TEXAS: *Scribner* in 1887.

MEXICO: *Schaffner* 1019 and 157, San Luis Potosí. *Pringle* 413, Chihuahua. *Wilkinson*, Santa Eulalia Mountains, Chihuahua. *Parry & Palmer* 943 $\frac{1}{2}$, San Luis Potosí.

11. *Bouteloua barbata* Lag.

Bouteloua barbata Lag. Var. Cienc. 2⁴: 141. 1805. This name has dropped out of recent literature, although it was correctly interpreted by Ruprecht, Roemer and

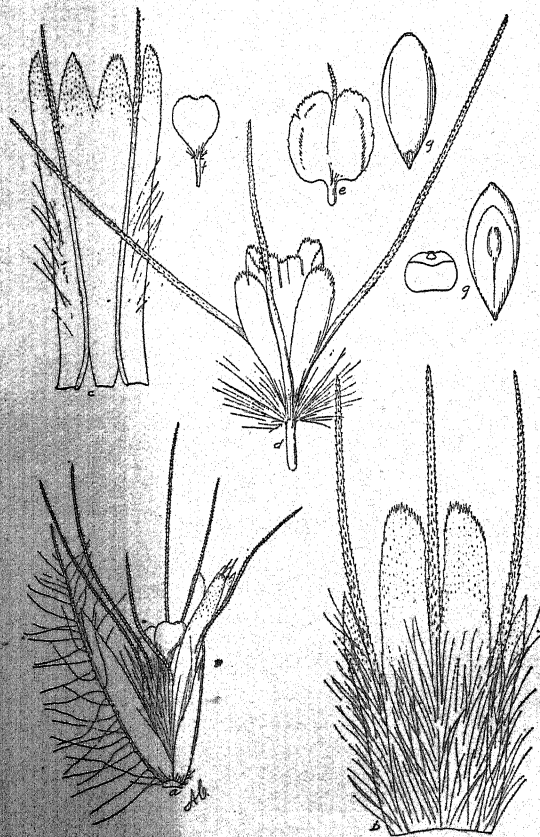
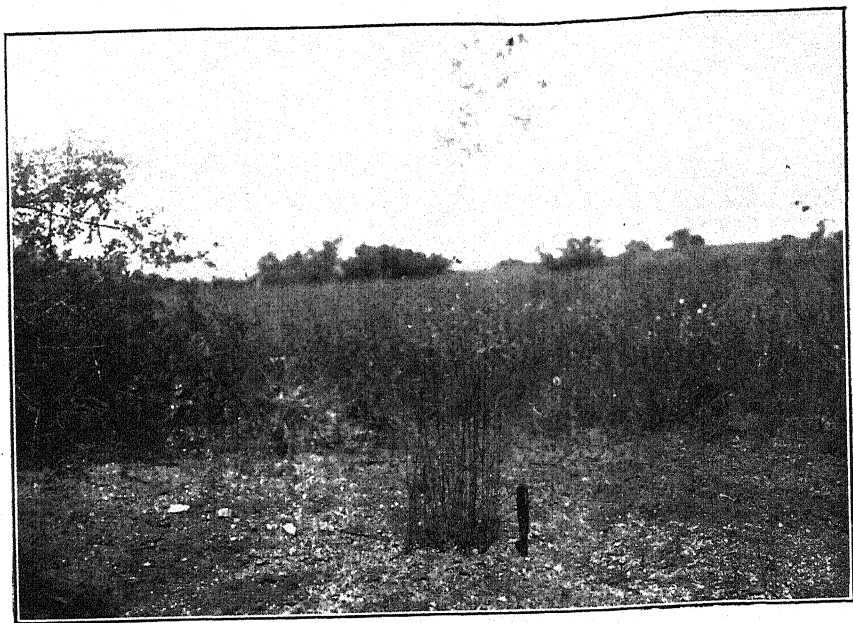
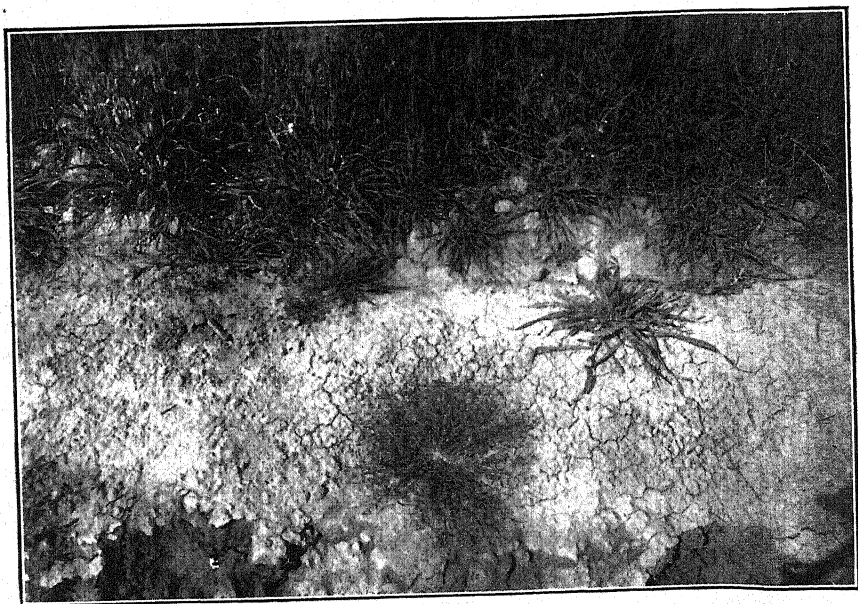


FIG. 37.—*Bouteloua parryi*. a, Spikelet; b, c, lemma and palea of first floret; d-f, rudimentary second, third, and fourth florets; g, two views and cross section of caryopsis. a, Scale 7.5; b-g, scale 12.5. a-f, From Griffiths 7277; g, from Wooton 3065.

EXPLANATION OF PLATE 73.—A. A clump of *Bouteloua parryi* consisting of several plants with those around removed. In situations like this, where many plants are found together, the habit is different from that wherein it grows in more isolated scattered bunches. B. An unusually large isolated tuft of *Bouteloua barbata*, Adamsana, Arizona.



A. LARGE PLANT OF *BOUTELOUA PARRYI* (FOURN.) GRIFFITHS.



B. *BOUTELOUA BARBATA* LAG.



Schultes, Kunth, and Steudel. A plant in the herbarium of the Botanic Garden at Madrid bearing this name in Lagasca's hand, is what in this country we have been calling *B. polystachya*. Of course this specimen is not the type, for Lagasca's first herbarium was burned, but this specimen named by him and his description, so far as it goes, applying to *B. polystachya*, leaves no doubt in my mind about the identity of the species.

Actinochloa barbata Roem. & Schult. Syst. Veg. 2: 420. 1817. Based upon *Bouteloua barbata* Lag.

Eutriana? barbata Kunth, Rév. Gram. 1: 96. 1829. Based upon *Bouteloua barbata* Lag.

Chondrosium polystachyum Benth. Bot. Voy. Sulph. 56. 1844. Through the kindness of the authorities at the Royal Botanic Gardens at Kew, I have been able to examine a liberal specimen of the type (*Barclay*, Magdalena Bay, Lower California). A specimen of the same collection is in the National Herbarium. Attention should be called to the fact that this is a very different species from the Palmer specimen^a from the Yaqui River region of Sonora, collected in 1869, said by Munro to be "typical."

Bouteloua polystachya Torr. U. S. Rep. Expl. Miss. Pacif. 5²: 366. pl. 10. 1857. Based upon *Chondrosium polystachyum* Benth.

Bouteloua pumila Buckl. Proc. Acad. Phila. 1863: 93. 1863. The type (*Wright* 754, Texas) is in the herbarium of the Philadelphia Academy.

Chondrosium exile Fourn. Mex. Pl. 2: 137. 1881. The type (*Berlandier* 842) in the Paris Herbarium is *Bouteloua barbata*. It is referred there to the genus *Chloris* and credited to Fournier, but so far as I know was never published in that genus. The specimen is a narrow-spiked, short-awned form. The same number in the Vienna Herbarium is the same species and is named "*Bouteloua barbata* Rupr."

Chondrosium microstachyum Fourn. Mex. Pl. 2: 138. 1881. The type (*Bourgeau* 667) is in the Paris Herbarium. Specimens of the same collection are also in the herbarium of the St. Petersburg Botanical Garden and in the National Herbarium, the former being labeled *B. oligostachya*.

Bouteloua microstachya Dewey, Contr. Nat. Herb. 2: 531. 1894. Based on *Chondrosium microstachyum* Fourn. Dewey considers *B. arenosa* Vasey and *B. polystachya* Benth. as in part synonymous with this.

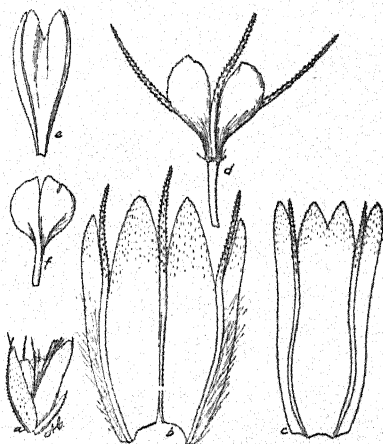


FIG. 38.—*Bouteloua barbata*. a, Spikelet; b, c, lemma and palea of first floret; d, e, rudimentary lemma and palea of second floret; f, rudiment of third floret. a, Scale 7.5; b-f, scale 20. From type specimen of *B. pumila*.

DESCRIPTION.

Plants exceedingly variable in both size and general aspect, erect when growing thickly, but prostrate when scattered, in favorable situations as much as 30 cm. high (as in *Griffiths* 6095) or prostrate, the tuft covering 3 or 4 square feet of surface, or consisting of single culms not over 3 cm. long; culms geniculate and freely branching when luxuriant, but mostly simple, especially if on sterile soil; sheaths loose, striate, smooth, comparatively short; blades short, flat, commonly 1 to 4 cm. long, divergent,

^a See *Bouteloua sonora*, page 389.

the ligule a ciliate, hairy ring; spikes 4 to 6 or 7, 1.5 cm. long; spikelets 25 to 40, about 3 mm. long over all, consisting of a floret and a rudiment; glumes hispid-keeled, short-awned, the awn subtended on either side by short, lanceolate-pointed teeth of the lamina of the glume, the first 2 mm., the second 3 mm. long; lemma 3.5 to 4 mm. long, densely hairy, having 3 equal, hispid awns, with 2 comparatively large, laminar teeth between them and a smaller one at either side; palet 3 mm. long, 2-awned and 4-toothed, bearing a few scattered hairs on the outside of the nerves; caryopsis oval, about 1 mm. long or less, rounded or slightly flattened on the back, the ventral surface nearly covered by the scutellum. (PLATE 73, B, facing p. 382. FIGURES 38, 39.)

The species is variable, sometimes growing a foot high and sometimes only an inch (see plate), its size depending upon the character of the soil and the amount of rain-

fall. In our Southwestern States and in Mexico east of the Pacific coast region it has two quite distinct forms, one with short awns, the other with long awns, making the spike much wider in the latter case. The long-awned form very closely approaches *B. arenosa* of the Pacific coast of Sonora, but that species has still heavier spikes. Further study, however, may require the inclusion of that species here. I do not feel warranted at present in making a change in the nomenclature, for my field experience has not brought me in contact with the *arenosa* form.

Pringle's 13626, Schaffner 183 and 187, Rothrock 352, Wootton 398, Bourgeau 667, Metcalfe 701, are all typical of this species, although showing some variation in the length of the awns and in the size of the plants,

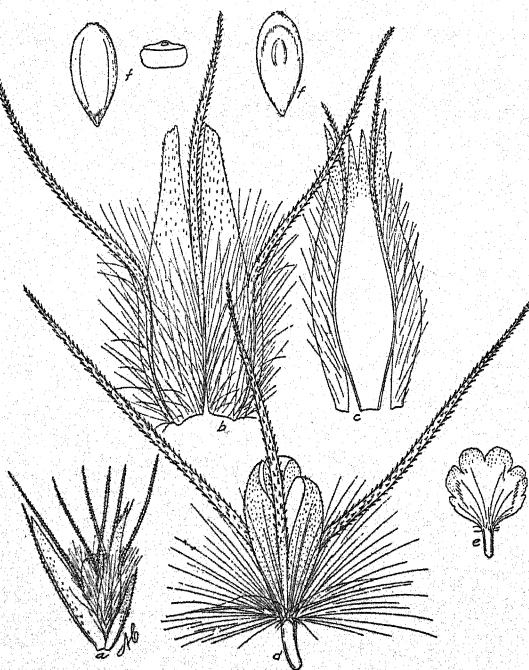


FIG. 39.—*Bouteloua barbata*. a, Spikelet; b, c, lemma and palet of first floret; d, e, rudimentary second and third florets; f, two views and cross section of caryopsis. a, Scale 7.5; b-f, scale 15. From Griffiths 6095.

and consequently a decided difference in general aspect. Two specimens, from Lower California, Brandegee, San José del Cabo, 1890, and Purpus, Cape Region, are doubtfully referred here.

HERBARIUM SPECIMENS.

ARIZONA: *Toumey* in Seymour's Grasses 85, Tucson. *Hitchcock* 3668, Patagonia; 3489, Tucson. *Purpus* 8293, Beaver Creek. *Blumer* 1706, Paradise. *Mearns* 1121, San Pedro River near Mexican boundary; 2765, Quitovaquito. *Griffiths* 1897, Wilcox; 2009, Benson; 1646, Sulphur Spring Valley; 1524, Tucson; 3400, Santa Rita Forest Reserve; 3360, Tucson. *Knowlton* 194, San Francisco Mountains; *Lemmon* 4644; *Davidson* 41a, Clifton; *Griffiths & Thorner* 254, Santa Rita Mountains. *Jones* 6063, Buckskin Mountains. *Rothrock* 352, Cottonwood. *MacDougal* 571, Fort Verde. *Leiberg* 5922, Grand Canyon at Bright Angel Trail.

CALIFORNIA: *Jones* 67a, Needles.

NEW MEXICO: *Wooton* 2923, north of Chamita; 2023, Las Cruces; 3063, Organ Mountains; 398, Dona Ana County. *Metcalf* 701, Silver City; 1395, Black Range. *Earle* 296, Roswell. *Plank* 15, Socorro. *Lemmon* 3147, Holbrook to Albuquerque. *Hitchcock* 3806, Organ Mountains. *Jones* 55a; *Tracy* 8190, Carlsbad. *Mearns* 2363, Dog Spring, Dog Mountains. *Mulford* 69, Florida Mountains.

NEVADA: *Cooper* 2241, Fort Mojave.

TEXAS: *Palmer* 1356, Guadalupe; *Tracy* 8217, Big Springs; 8207, Fort Worth; *Cockerell* 15, Fort Bliss. *Jones* 641, 13a, and 4341, El Paso. *Havard* in 1882, Eagle Pass. *Nealley* 103, Laredo.

UTAH: *Jones* 5702a, Junction; 5696, Cainville; 5652, Capitol Wash. *Thompson* 339.

MEXICO: *Brandgee*, San José del Cabo, Lower California. *Palmer* 508, La Paz, Lower California and Guaymas; 857, Carmen Island; 714, Durango; 400 and 401, Saltillo. *Schaffner* 152 and 1017, San Luis Potosí; 153, Valley of Mexico. *Pringle* 490, Chihuahua; 11216 and 13626, Jimulco. *Barclay*, Lower California. *Parry* & *Palmer* 946, San Luis Potosí. *Smith* 957, San Antonio Valley, Oaxaca. *Pittier* 470, State of Durango.

12. *Bouteloua arenosa* Vasey.

Bouteloua arenosa Vasey, U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 34^a. 1890. The first use of the name was by Watson,^b but no description is given. The type is *Palmer* 189, Guaymas, Sonora, Mexico, 1887, in the National Herbarium.

DESCRIPTION.

A tufted, smooth, erect or decumbent annual, with sparingly branched, simple or geniculate culms, 10 to 15 cm. long; sheaths striate, rather loose, especially in branching individuals, the ligule conspicuous, consisting of a white, ciliate fringe 1 to 1.5 mm. long; blades 3 to 4 cm. long, rather sparse in the majority of specimens, but plentiful in others; panicle racemose, 3 to 6 cm. long; spikes 2 to 4, about 1.5 cm. long, mostly recurved; spikelets 16 to 20, pectinate, consisting of a lower perfect floret and an upper rudiment; first glume 1 to 1.7 mm., the second about 3 mm. long, the keels very minutely scabrous, usually 2-toothed with short awns between the teeth; lemma 4-toothed, about 4.5 mm. long including the 3 long, scabrous, equal awns, about 3 mm. long, completely covered on the back with long, white hairs 1 mm. or more in length; palea 4-toothed, 3 mm. long, including the scabrous awns, about 1.3 mm. long, with a white, hairy, ciliate fringe outside of the nerves, the awns being a continuation of these; rudiment 5 mm. long, consisting of three approximately equal, scabrous awns, 3 mm. long, alternating with the obovate lobes of the lemma and supported upon a short, hairy-tufted stipe; caryopsis obovate, 1 mm. long, 0.4 mm. wide, the scutellum covering about two-thirds of the ventral surface. (FIGURE 40.)

The species is to be looked upon as a long-awned form of *B. barbata*, which appears to be characteristic of the coast of Sonora. Dr. Palmer's notes indicate that the type was collected in loose, sandy soil.

It is quite doubtful in my mind whether *B. arenosa* is really specifically distinct from *B. barbata*, but I hesitate to reduce it, because my experience in the field in this particular locality is very limited. It must be confessed, however, that there are forms of *B. barbata* in Arizona and New Mexico which approach this in the one character which has served to separate it; that is, the length of the awns. However, only the specimens enumerated below have awns as short as those of *B. barbata*, the Arizona forms referred to *B. barbata* having awns only two-thirds to three-fourths as long. We have here the same sort of differences that we have in *B. rothrockii* and its allies.

^a The figure is very misleading.

^b Proc. Amer. Acad. 24: 81. 1889.

Besides several sheets of the type collection there are in the National Herbarium two specimens collected by Orcutt in Lower California in 1889 and 1890 and one by Hayes at "Puachio," Arizona, in 1858. All of these differ only in having longer awns from forms of *B. barbata* which I know in the field.

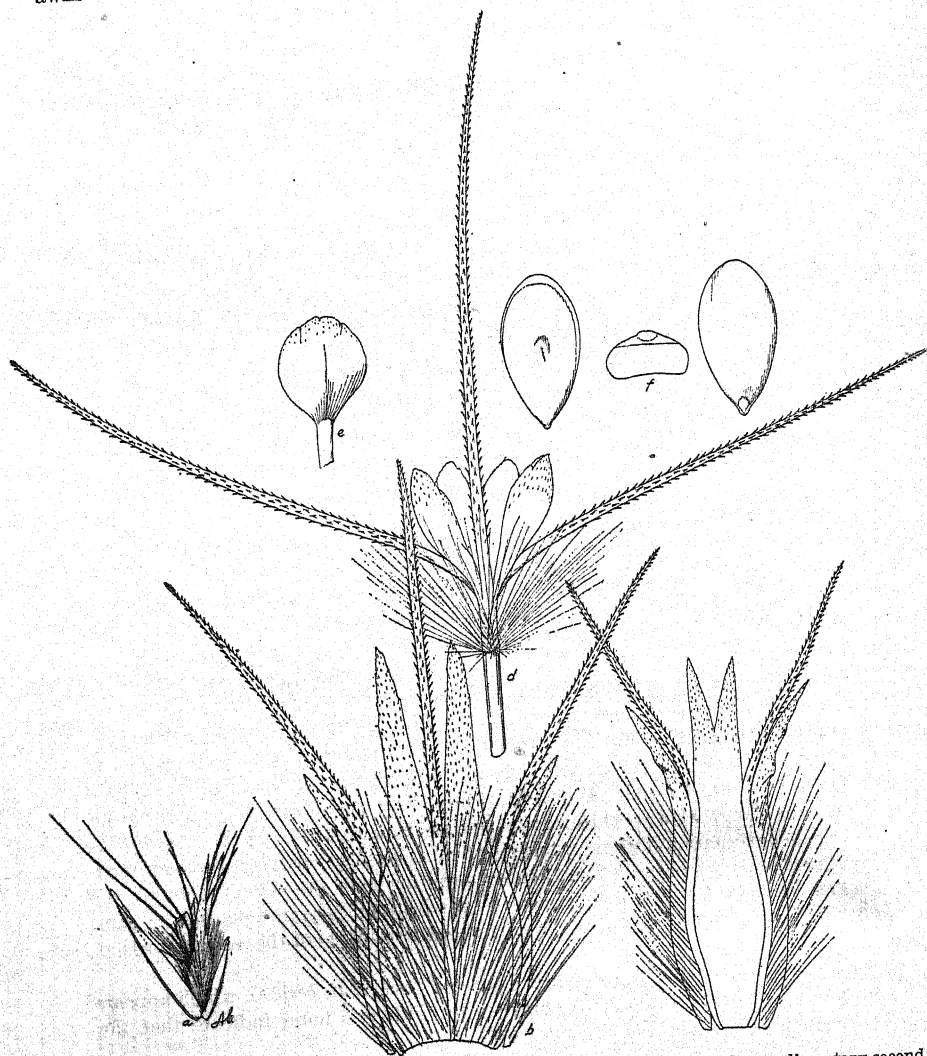


FIG. 40.—*Bouteloua arenosa*. a, Spikelet; b, c, lemma and palea of first floret; d, e, rudimentary second and third florets; f, two views and cross section of caryopsis. a, Scale 7.5; b-f, scale 20. From type specimen.

HERBARIUM SPECIMENS.

ARIZONA: Hayes, Puachio. Mearns 929, south of Bisbee.

CALIFORNIA: Orcutt, Colorado Desert.

TEXAS: Buckley in 1883.

MEXICO: Palmer 189, Guaymas. Hitchcock 3534, Hermosillo. Orcutt, Lower California in 1889.

13. *Bouteloua trinitii* (Fourn.).

Chondrosium trinitii Fourn. Mex. Pl. 2: 136. 1881. A duplicate of the type (*Berlandier* 1427, Laredo, Texas), in the National Herbarium, and a photograph and fragment of the type from the herbarium of the Paris Muséum are before me.

Chondrosium (?) *polystachyum* Trin.; Fourn. Mex. Pl. 2: 136. 1881. This herbarium name is given as a synonym of *Chondrosium trinitii*.

Bouteloua trifida Thurb. in Wats. Proc. Amer. Acad. 18: 177. 1883. The type, in the Gray Herbarium, is *Palmer* 1355, Monclova, Coahuila, Mexico, 1880. See also U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 46. 1890; U. S. Dept. Agr. Div. Agrost. Bull. 7: 224 and 225. f. 206 and 207. 1897.

Bouteloua burkii Scribn. in Wats. Proc. Amer. Acad. 18: 179. 1883; Bull. Torrey Club 11: 5. 1884. The type, as considered by Scribner in the latter publication, was collected at Laredo, Tex., by Mrs. Anna B. Nickels. This specimen appears to have been destroyed when Scribner's herbarium was burned. *Berlandier* 167, which is the first specimen cited by Watson, probably was burned at the same time, at least this does not appear to be now in the Gray Herbarium. *Berlandier* 1427, cited in the original description, is in the National Herbarium, *Curtiss* 3440* also cited, is in the herbarium of the Missouri Botanical Garden and the National Herbarium. See also U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 36. 1890.

Watson's paper^a was published August 23, 1883. Here he describes *B. trifida* Thurb., basing it upon *Palmer* 1355, Monclova, Coahuila, Mexico. He also lists *Parry & Palmer* 945 and *Wright* 749, 2020, and 2022, and describes *B. burkii*

Scribn., basing it upon *Berlandier* 167 and 1427, and *Curtiss* 3440. Scribner^b publishes the same species again. Under *B. trifida* Scribner lists: "Texas and New Mexico; G. R. Vasey, Mexico; Dr. E. Palmer No. 1355, 1880." Under *B. burkii* he lists the following: "Laredo, Texas; Mrs. Anna B. Nickels; communicated to me by Mr. Isaac Burk, of Philadelphia, for whom the species is named. Sandy plains, Upper Concho, West Texas; J. Reverchon; No. 3440*, *Curtiss's* Distribution North American Plants."

In the National Herbarium a specimen collected by Letterman, Laredo, Tex., July, 1882, is marked the type of *B. burkii*, and another collected by G. R. Vasey, El Paso, Tex., 1881, the type of *B. trifida*, both in Scribner's hand.

DESCRIPTION.

A variable, low, delicate, caespitose perennial, with comparatively naked culms, 12 to 15 cm. high, but very variable in size, erect, or, in old, undisturbed plants,

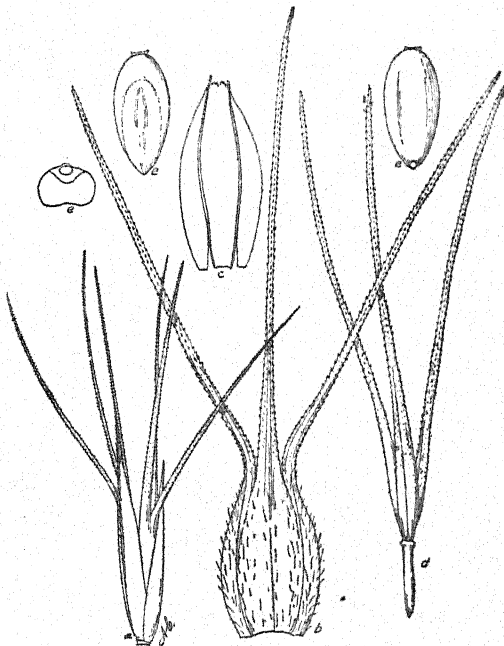


FIG. 41.—*Bouteloua trinitii*. a, Spikelet; b, c, lemma and palea of first floret; d, rudiment; e, two views and cross section of caryopsis. a, Scale 7.5; b-e, scale 12.5. From Griffiths 6104.

^a Proc. Amer. Acad. 18: 176-180. ^b Bull. Torrey Club 11: 5. January, 1884.

geniculate at the very base; sheaths close, striate, smooth or very minutely roughened-hispidulous, with ciliate-fringed ligule and minutely pubescent, hispid blades, bearing a few long, scattered, papillose hairs, divaricate, 1 to 2 cm. (*Letterman*, Laredo, 1882) to 3 to 7 cm. long (*Griffiths* 6338); panicle racemose, 4 to 7 cm. long, bearing 3 to 7 spikes, 1 to 1.3 cm. long, bearing about 12 pectinately arranged spikelets 7 to 8 mm. long; spikelets consisting of one fertile floret and a rudiment; glumes about equal, smooth, keeled, about 2.5 mm. long; lemma hairy, 4 to 5 mm. long, bearing 3 scabrous awns about 3 mm. long; palet 2-keeled, not awned, about 1.5 mm. long; rudiment consisting of 3 hispid, equal awns, enlarged at base, about 4 mm. long, upon a naked stipe 1 mm. long or less; caryopsis obovate, 0.8 mm. long, 0.3 mm. wide, the scutellum somewhat oval, two-thirds the length of seed. (PLATES 74, A; 78. FIGURES 41, 42.)

Like many other species of the genus this is very variable in size and general aspect. The specimens marked type in the National Herbarium, as mentioned above, while not the nomenclatorial types, are nevertheless typical of what was intended to be published under these two names. For nomenclatorial purposes I consider them as

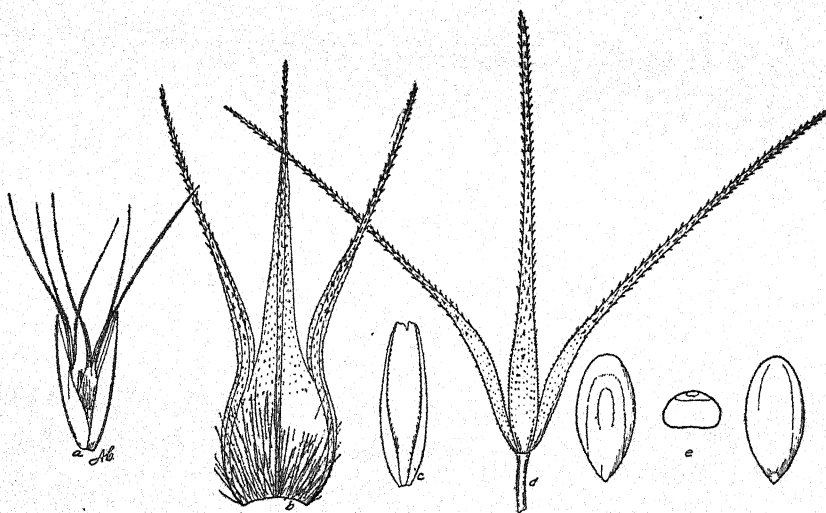


FIG. 42.—*Bouteloua trinitii*. a, Spikelet; b, c, lemma and palet of first floret; d, rudiment; e, two views and cross section of caryopsis. a, Scale 7.5; b-e, scale 15. a-d, From *Letterman*, Laredo, Tex. (typical of *B. burkii*); e, from *Griffiths* 6338.

good as types. *Bouteloua burkii* and *Chondrosium trinitii* are the same form of plant; that is, the shorter awned, more leafy plant, with longer, laxer leafage.

Westward from about the region of Del Rio, Texas, the species is inclined to assume a slightly different aspect. Especially is this true from the region of El Paso to Arizona. The plant is somewhat dwarfed, the leaves are fewer, shorter, and more rigid, and the awns slightly longer. In short, the same differences occur in this species upon entering more arid situations as are found in *B. gracilis* in southern California where the leaves become more radical, shorter, and more rigid, compared with those of more humid sections.

In the Rio Grande region the species is very important from the stockman's standpoint, for it often constitutes the sum total of the forage upon the alluvial soils of the shallow ravines and also extends onto the rocky knolls and ridges.

When closely grazed it is short, with divaricate, crowded leaves near the base and comparatively naked culms. When unmolested and consequently somewhat shaded

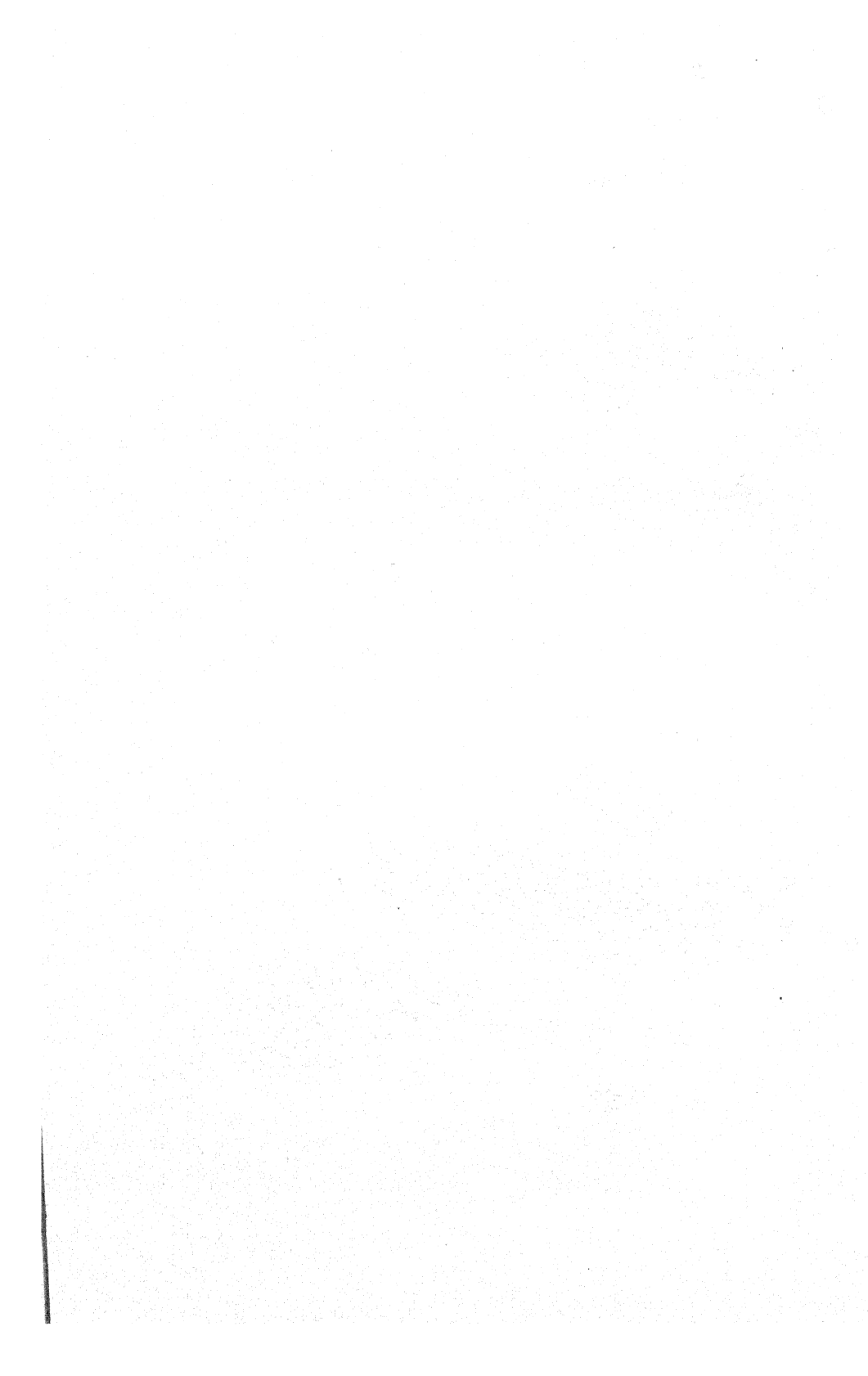
EXPLANATION OF PLATE 74.—A. *Bouteloua trinitii* as it grows in arid situations near Andrade, Arizona. Here we always have the form described as *B. trifida*. B. An extraordinarily large bunch of *Bouteloua eriopoda* from the Santa Rita Mountains, Arizona.



A. *BOUTELOUA TRINII* (FOURN.) GRIFFITHS.



B. *BOUTELOUA ERIPODA* TORR.



by old growth at its base, the leaves are more lax, ascending, and longer, and the culms are more leafy above.

Specimens are abundant in American herbaria. They are usually referred to *B. burkii* and *B. trifida* in about equal numbers. The range of the species is from the Rio Grande region of Texas southward to San Luis Potosí and westward to Tucson, Arizona.

HERBARIUM SPECIMENS.

The following are typical of *B. burkii*:

TEXAS: *Reverchon* 162, Coleman and Tom Green Counties; 1361 $\frac{1}{2}$ and 1361,^a Llano; 1408, Sabinal Canyon; 3440, Upper Concho, in Curtiss N. Amer. Plants. *Jerny*, Bexar County. *Smith* 97, San Diego. *Tracy* 8230, Colorado; 8896, Kingsville. *Nealley*, Cotula, 1888. *Piper*, Kingsville, 1906. *Letterman*, Laredo, July, 1882. *Berlandier* 1427.

MEXICO: *Pringle* 1974 and 11735, Monterey; *Palmer* 370, Victoria.

The following herbarium specimens are typical of *B. trifida* (Pl. 74, A.):

ARIZONA: *Pringle*, mesas near Tucson, 1884. *Griffiths* 2448, Tucson.

NEW MEXICO: *Wright* 2022 of 1851-52.

TEXAS: *Vasey*, El Paso, 1881. *Reverchon* ^b 1408 (Texas Plants), Sabinal Canyon.

MEXICO: *Palmer* 522 and 402, Saltillo.

The following specimens appear to stand midway between the two forms in some characters, usually due to long awns combined with softness and laxity of leafage:

ARIZONA: *Lemmon*, Hackberry 1889.

TEXAS: *Canby* 270, Spofford Junction. *Reverchon* 37; 361, Llano (Texas Plants); 1408, Sabinal Canyon. *Jerny* 212, Bexar County. *Plank*, El Paso, 1894; 1, Llano. *Havard* 30, mouth of Pecos. *Mearns* 1215, Fort Clark.

MEXICO: *Pringle* 412, Chihuahua. *Palmer* 552, Victoria; 1355, Monclova. *Parry & Palmer* 945, San Luis Potosí. *Wilkinson*, Santa Eulalia Plains, Chihuahua, 1885. *Mearns* 1201, La Noria, Sonora.

14. *Bouteloua sonoreae* sp. nov.

DESCRIPTION.

A low, spreading, or half-erect perennial, 12 to 15 cm. high; culms simple, stoloniferous or simply geniculate; sheaths close, striate, smooth, the ligule a rather long fringe of white hairs; blades mostly radical, narrow, short, acuminate, 5 to 10 cm. long, decreasing upward to often 1 cm. long, revolute; panicle racemose, about 4 cm. long; spikes 2 to 4, mostly 4, about 12 to 14 mm. long, recurved at the apex; spikelets about 30, pectinate, about 2.5 mm. long, consisting of a lower perfect floret and an upper rudiment; glumes smooth except for a few long white hairs on the keel, not awned, the second 1.5 mm. long, the first a little shorter; lemma hairy, 3-nerved, shortly 3-awned, 2.3 to 2.5 mm. long, including awns; palet concave, shortly 2-awned, a trifle shorter than its lemma; rudiment of 3 awns interspersed with short, blunt scales upon a short, hairy-tufted stipe, about 0.5 mm. long; caryopsis not seen. (FIGURE 43.)

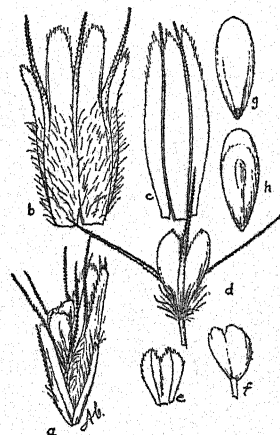


FIG. 43.—*Bouteloua sonoreae*. a, Spikelet; b, c, lemma and palet of first floret; d, e, rudimentary lemma and palet of second floret; f, rudiment of third floret; g, h, two views of caryopsis. a, Scale 7.5; b-h, scale 10. From type specimen.

^a Typical *B. burkii* and *B. trifida* are on the same sheet of no. 1361, Texas Plants.

^b Three sheets of this are placed in as many groups.

The species is to be looked upon as a perennial *B. barbata*, a native of the west coast of northern Mexico. The type is Palmer's Yaqui River specimen of 1869 in the National Herbarium. Palmer 751, Alamos, Mexico, 1890 and W. G. Wright 1322 from the headwaters of Mazatlan River are distinctly stoloniferous, while Hitchcock 3552, Guaymas, Mexico, is simply geniculate and a much larger plant than any of the others. The same is true of Chase 5509 from near Guaymas.

15. *Bouteloua eriopoda* (Torr.) Torr.

Chondrosium eriopodum Torr. in Emory, Mil. Recon. 154. 1848.

Bouteloua eriopoda Torr. U. S. Rep. Expl. Miss. Pacif. 4: 155. 1856. Based upon *Chondrosium eriopodum*. See also U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 37. 1890; U. S. Dept. Agr. Div. Agrost. Bull. 7: 217. f. 199. 1897.

Bouteloua brevifolia Buckl. Proc. Acad. Phila. 1862: 93. 1862. Asa Gray^a reviews Buckley's descriptions and refers this to *B. eriopoda* Torr. and shows that it was based upon Wright's no. 748 and Fendler's no. 950 (not 946 as on ticket in the Philadelphia Academy Herbarium).

DESCRIPTION.

A caespitose perennial, growing commonly in large bunches, separated by intervals of a few inches to a few feet of bare ground, or occasionally a weedy annual, but seldom in shade of shrubs; culms geniculate, rather weak, woolly, 40 to 60 cm. long, commonly branched, and in warmer localities sparingly perennial, with close, striate, smooth sheaths, small ciliate-fringed ligule, and narrow, convolute, smooth blades; panicle racemose, 10 to 15 cm. long; spikes 3 to 8, commonly 4 or 5, 2 to 3 cm. long; spikelets 12 to 20, 7 to 10 mm. long, loosely pectinate, consisting of one lower fertile floret and an upper rudiment; glumes very unequal, the first about 3 mm., the second about 7 mm. long, keeled, smooth, or the second minutely scabrous at the apex; lemma minutely hairy below, 3-awned, the lateral awns very short, the central equaling those of the rudiment, hispid, 2 mm. long; palet awnless, acuminate, about 5 mm. long; rudiment consisting of 3 equal, hispid awns 4 mm. long, united at base by very minute scales and supported upon a slender, smooth stipe 2 mm. long, hairy-tufted at each end; caryopsis cylindrical-oblong, 2.5 to 3 mm. long, 0.25 to 0.35 mm. wide, the scutellum covering three-fourths of the ventral surface. (PLATE 74, B, facing p. 388. FIGURE 44.)

FIG. 44.—*Bouteloua eriopoda*. a, Spikelet; b, c, lemma and palet of first floret; d, rudiment; e, two views and cross-section of caryopsis. a, Scale 7.5; b-e, scale 10. From Griffiths 7002.

The lax, pectinate inflorescence and woolly culms readily distinguish this species. In publications of the United States Department of Agriculture it has usually been called "woolly-foot" but in portions of the Rio Grande Valley of New Mexico, where

^aProc. Acad. Phila. 1862: 334. 1863.

it is most abundant, "black grama" is the name by which the stockmen know it. In and adjacent to the Mesilla Valley it occupies large stretches of the open, gently sloping country between the rugged upper foot-hills and the brushy regions of the lower foothills and mesas above the bottom lands. The crop here in exceptionally favorable years is heavy enough to be mown for hay. No other region is known which makes such a heavy crop, although it is an abundant and familiar grass throughout the arid Southwest and extends far into Mexico.

There has never been much confusion regarding its identity, and although very variable the species is easily distinguished when once recognized. *Wright* 18 and 748; *Jones* 54a; *Pringle* 411; *Mearns* 2267 and 2089; and *Wootton* 458 are typical.

HERBARIUM SPECIMENS.

ARIZONA: *Griffiths* 1825, Mescal; 1669, Rincon Mountains; 3395 and 3367, Santa Rita Forest Reserve. *Jones* 6067, Pipe Spring; 4262, Bowie; *Griffiths & Thorner* 1, Santa Rita Forest Reserve; 233, Empire Ranch. *Leiberg* 5931, Bright Angel Trail, Grand Canyon. *Mearns* 865, south of Bisbee; *Rushy* 892, Yavapai County. *Purpus* 8276, Beaver Creek. *Toumey*, Chiricahua Mountains.

NEW MEXICO: *Plank* 18 and 5, Socorro. *Griffiths* 3337, Deming. *Mearns* 2333, Dog Mountains. *Metcalfe* 631, 1451, Kingston; *Wright* 2018; *Jones* 54a, Albuquerque. *Wootton & Standley*, Tortugas Mountains; 3973, east of Dona Ana Mountains. *Hitchcock* 3740, Deming; 3787, Organ Mountains. *Wootton* 458, Las Cruces.

TEXAS: *Plank* 69, El Paso. *Tracy* 8283, Barstow. *Carleton* 417, Oldham County.

MEXICO: *Pringle* 411, Chihuahua. *Wilkinson* 348, Santa Eulalia Plains, Chihuahua. *Mearns* 2089, base of San Luis Mountains, Mexican Boundary.

16. *Bouteloua rothrockii* Vasey.

Bouteloua polystachya major? Vasey in Wheeler, Rep. U. S. Surv. 100th Merid. 6: 287. 1878. This is based upon Rothrock's no. 691, Sonoita Valley, Arizona, September, 1874. The specimen is in the National Herbarium. It is the narrow-spiked form, typical of *B. micrantha* Scribn. & Merr. See also Vasey, Grasses U. S. 33. 1883, and Descr. Cat. Grasses 63. 1885. Both this variety and *B. rothrockii* are listed in the former reference.

Bouteloua rothrockii Vasey, Grasses U. S. 33. 1883, name only; Contr. Nat. Herb. 1: 268. 1893, containing the first description. The type is Rothrock's no. 347, Cottonwood, Arizona, 1874. See also U. S. Dept. Agr. Div. Agrost. Bull. 7: 221. f. 203. 1897.

Bouteloua micrantha Scribn. & Merr. U. S. Dept. Agr. Div. Agrost. Circ. 32: 8. 1901. Based upon *Griffiths* 1556, Fort Lowell, Arizona, September, 1900. This is a narrow-spiked form of *B. rothrockii* grown under favorable circumstances in an irrigated, poorly cultivated field. It is typical of *B. polystachya major*? Vasey.

DESCRIPTION.

A tufted, erect, sparingly branched, smooth, short-lived perennial, 25 to 50 cm. high; sheaths striate, smooth, rather tightly fitting but often open at maturity, the ligule reduced to a ciliate fringe; blades abundant toward the base of culm, 6 to 10 cm. long, 2 to 3 mm. wide, smooth or usually with a few long, scattered, delicate, papillose hairs on the upper surface and edges, the margin minutely serrate; panicle racemose, 10 to 25 cm. long; spikes 4 to 10 or 12, 2.5 to 3 cm. long and 5 mm. wide; spikelets pectinate, 40 or 50, about 6 mm. long, including awns; glumes minutely scabrous, keeled, the first about one-half the length of the second and with an awn about 1 mm.

long; lemma about 5 mm. long, loosely hairy, with long, white hairs, the four teeth fringed or frayed into minute, hair-like teeth, with 3 scabrous awns, 1 to 1.5 mm. long, palea 4-notched, two-nerved with two scabrous awns, hairy on the edges and laciniate at apex like the lemma, 4 mm. long; rudiment consisting of two rudimentary florets, the lower composed of rudimentary scale-like glumes and three long, scabrous awns (about 3 mm. long), subtended by a tuft of long, straight, white hairs, all borne upon a naked stipe 1 mm. long; second rudiment consisting of scale-like glumes upon a naked, short stipe; caryopsis ovate to obovate, about 1.25 mm. long, the scutellum covering nearly the entire ventral surface. (PLATE 75, A, B. FIGURES 45, 46.)

There are large areas in southern Arizona and neighboring regions where this is the most important grass of the stock ranges. It inhabits the upper mesas and the

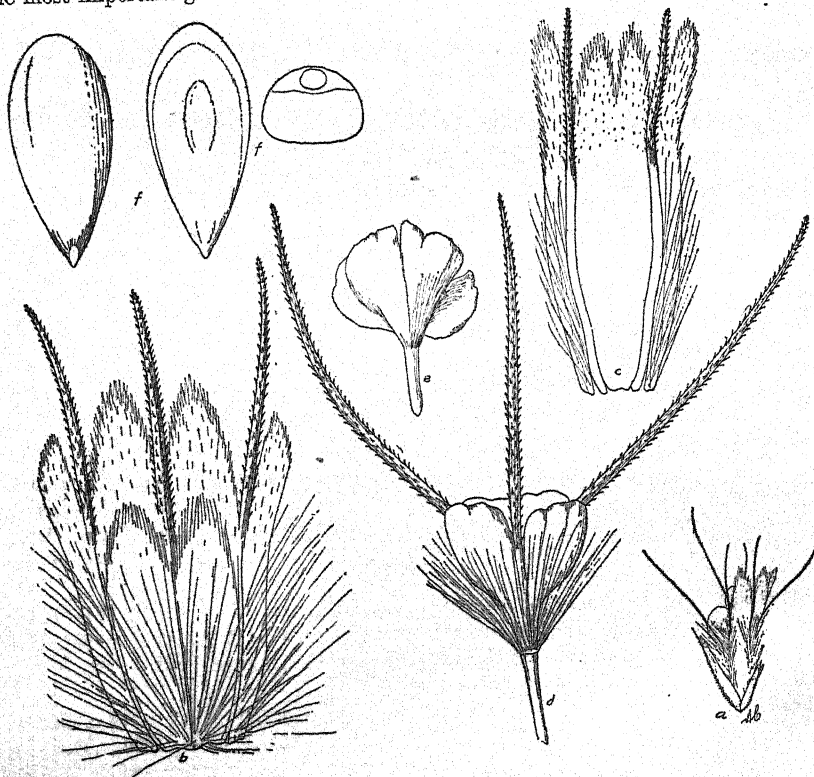
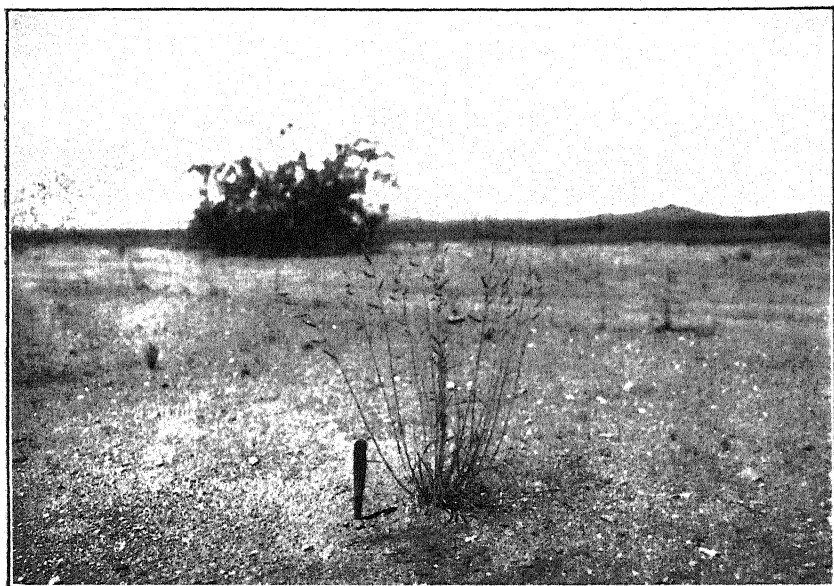


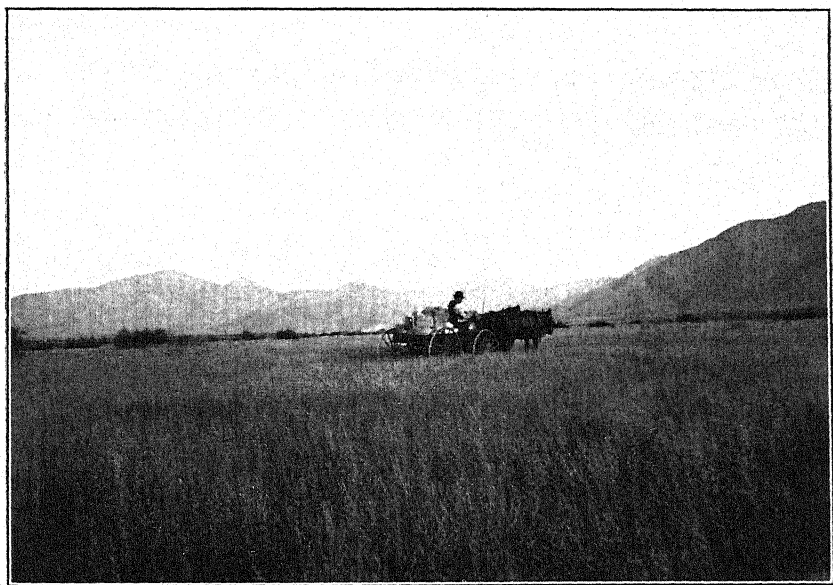
FIG. 45.—*Bouteloua rothrockii*. a, Spikelet; b, c, lemma and palea of first floret; d, e, rudimentary second and third florets; f, two views and cross-section of caryopsis. a, Scale 7.5; b-f, scale 20. a-e, From type specimen; f, from Griffiths 7185.

gentle, brushless slopes of the foothills during the summer rainy season, July to September, often to the exclusion of all other species. It is a very characteristic species, and although often appearing to intergrade with *B. barbata* it is very distinct and easily distinguished in the field. There are many specimens, however, which are very difficult to separate from *B. barbata* on the herbarium sheet. When the

EXPLANATION OF PLATE 75.—A. An isolated tuft of *Bouteloua rothrockii* on desert east of Tucson, Arizona. B. A large native crop of *Bouteloua rothrockii* in southern Arizona. This area had not been pastured for five years.



A. ISOLATED PLANT OF *BOUTELOUA ROTHROCKII* VASEY.



B. DENSE GROWTH OF *BOUTELOUA ROTHROCKII*.



species is nearing maturity, the landscape is tinted reddish brown by the abundant spikes. In some sections it grows so abundantly that ranchers consider it profitable to cut it for hay. So far as my own observation goes it never yields over one-half ton to the acre of clean, current year's growth (Pl. 75, B). In southern Arizona, upon a rainfall of 12 to 18 inches, it grows about 8 inches in the growing season, July to September.

Bouteloua rothrockii is not a grass that withstands close pasturage well. Being a short-lived perennial and a comparatively poorly rooted species, it is easily pulled up and trampled out. The best growths of it today are found in those regions which are at a considerable distance from water available for stock.

It grows in bunches of a few culms to scores of culms, but so far as my observation goes never makes any semblance of a turf. When it happens to grow on partly cultivated ground or in other favorable situations, the bunches may grow very large and the outer culms of the stool become geniculate and even rooted at the joints. Some

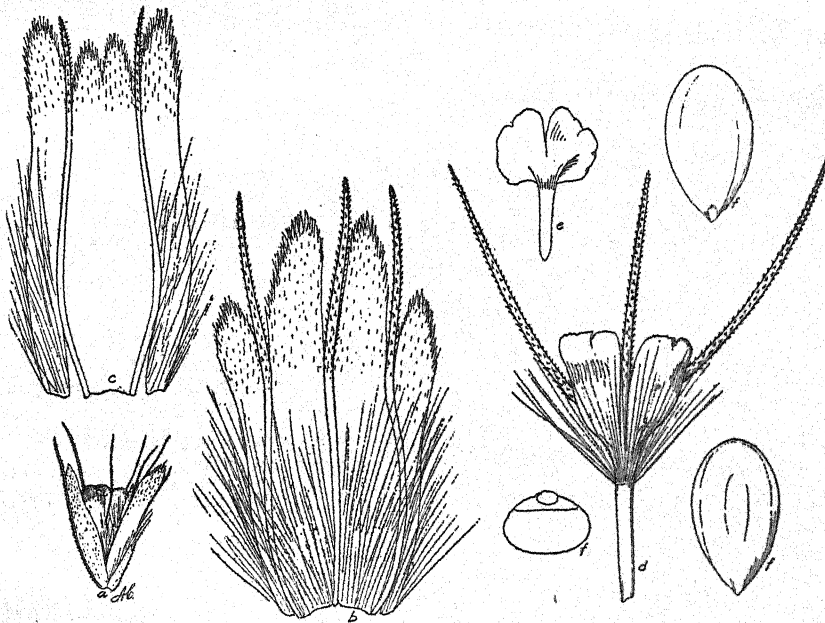


FIG. 46.—*Bouteloua rothrockii*. a, Spikelet; b, c, lemma and palea of first floret; d, e, rudimentary second and third florets; f, two views and cross-section of caryopsis. a, Scale 7.5; b-f, scale 20. From type specimen of *B. micrantha*.

of my specimens from cultivated ground in the upper Santa Cruz Valley of Sonora show this form of the plant beautifully.

My conception of the species is well illustrated by the specimens cited below. *Rothrock* 691 and *Griffiths* 1556 have narrow spikes and smaller floral parts throughout than the common typical form (Pl. 75, A).

Palmer's no. 244 and *Pringle* 221 very well represent the common form. *Brandege*, Culiacan, Mexico, October, 1904, and *Palmer* 204, 1534, and 1761, are geniculate forms. *Purpus* 94 and *Pringle*, Arizona, in 1884 without number, represent forms which have about the same relation to the typical species as *B. arenosa* has to *B. barbata*. In these the awns are exceptionally long and the spike very wide.

HERBARIUM SPECIMENS.

ARIZONA: *Hitchcock* 3685, Patagonia; 3480, Tucson; 3733, Benson. *Griffiths* 1556, Fort Lowell; 3361, near Tucson; 3402, Santa Rita Forest Reserve; 1785, Rincon Mountains. *Mearns* 1026, 1064, and 856 $\frac{1}{2}$, south of Bisbee. *Griffiths & Thornber* 199 and 9, Santa Rita Mountains. *Purpus* 94, Antelope. *Pringle* in 1884 near Mexican Boundary. *Rothrock* 691, Sonoyta Valley; 347, Cottonwood. *Nealley*, Tanque Verde. *Wilcox*, Fort Huachuca. *Jones* 4014, Flagstaff. *Lemmon* 429, 430. *Toumey* 807, and 512, Tucson.

UTAH: *Jones*, Moab.

MEXICO: *Hitchcock* 3583 and 3536, Hermosillo; 3523, Llano. *Palmer* 235, 166, and 204, Guaymas; 791, Agiabampo; 1543, Culiacan; 1761, Ymala. *Brandege*, Culiacan.

17. *Bouteloua karwinskii* (Fourn.).

Chondrosium karwinskii Fourn. Mex. Pl. 2: 137. 1881. The type is *Karwinski* 1479 from "Cañon de las Minas et Victoria," Mexico. This number was not found in the Paris Herbarium. My interpretation is based upon a panicle and two leaves of this number from the herbarium of the St. Petersburg Botanical Garden. *Hemsley*^a lists this as one of Fournier's unidentified species, but gives the range as extending from Texas to South Mexico and a specific locality as La Miquiguana. I have seen no collections of the species except as noted below and can not say anything about the basal portion of the type plant nor its duplicates, having seen only a panicle and some leaves. These, however, agree so well with recent collections that I have no hesitancy in referring them here.

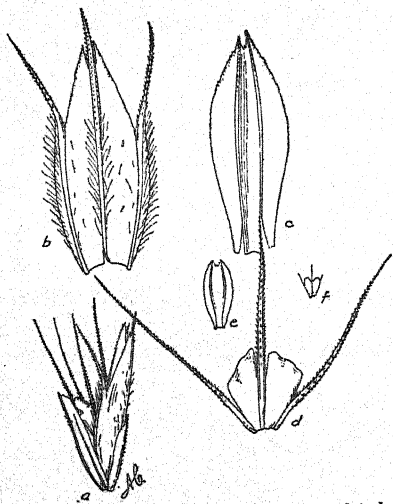


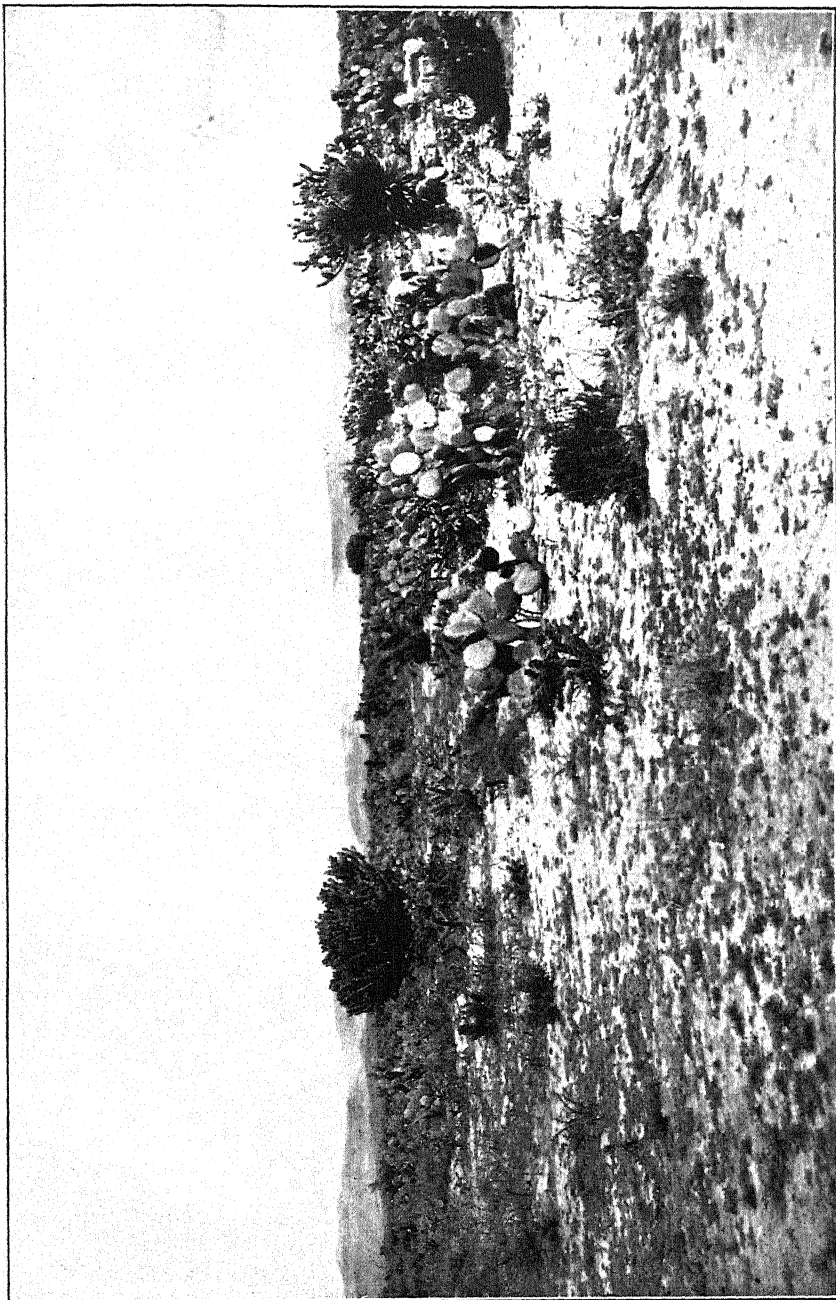
FIG. 47.—*Bouteloua karwinskii*. a, Spikelet; b, c, lemma and palea of first floret; d, e, rudimentary lemma and palea of second floret; f, rudiment of third floret. a, Scale 6.66+; b-f, scale 10. From *Karwinski* 1479, in St. Petersburg Herb.

DESCRIPTION.

An erect, caespitose, gray-glaucous, rigid perennial, with stout, short, rhizomatous base; culms simple, erect, 20 to 30 cm. high; sheaths striate, smooth, close, the ligule reduced to a few long, white hairs; blades narrow, mostly basal, variable, about 7 cm. long and 1 to 1.5 mm. wide; panicle racemose, about 10 cm. long; spikes 12 to 14 mm. long and 5 or 6 in number; spikelets pectinate on a flattened, short, hairy, zigzag rachis, consisting of a lower perfect and an upper three-awned rudiment, with scales and awns arising from a naked stipe about 1 mm. long; glumes smooth, the second about 2 mm. long, the first a little shorter, acuminate, scarcely awned; lemma 2 to 2.5 mm. long, pubescent, with 3 equal awns; palea about the length of its lemma, with 2 very short awns, plicate; caryopsis not seen. (PLATE 76. FIGURE 47.)

^a Biol. Centr. Amer. Bot. 3: 564. 1885.

EXPLANATION OF PLATE 76.—Natural habitat of *Bouteloua karwinskii*, *B. trinii*, and *B. stolonifera* among vegetation consisting largely of *Cereus*, *Opuntia*, *Jatropha*, etc., east of San Luis Potosí, Mexico.



HABITAT OF *BOUTELOUA KARWINSKII* (FOURN.) GRIFFITHS, *B. TRINII* (FOURN.) GRIFFITHS, AND *B. STOLONIFERA* SCRIBN.

The species appear to be native from San Luis Potosí northward. It is distinguished by its strong, harsh, woody base and by its spikes, which, although they resemble those of *B. barbata*, are slightly wider and shorter.

The first material seen was collected by myself near Alonzo, Mexico, March 14, 1905 (no. 7650). All specimens were of the previous year's growth, and consequently not satisfactory. Recently Lloyd has contributed very materially to a knowledge of the species by two collections (nos. 170 and 183) from Hacienda de Cedros, in northern Zacatecas. These and a panicle of a duplicate of the type are all the material which has been seen.

18. *Bouteloua alamosana* Vasey.

Bouteloua alamosana Vasey, Contr. Nat. Herb. 1: 115. 1891. Edward Palmer's no. 698, Alamos, Sonora, Mexico, September 10 to 30, 1890, is the type.

DESCRIPTION.

A tufted, sparingly hairy annual with geniculate, ascending or prostrate, sparingly branched culms, 4 to 20 cm. high; sheaths striate, rather loose, with scattered, papil-

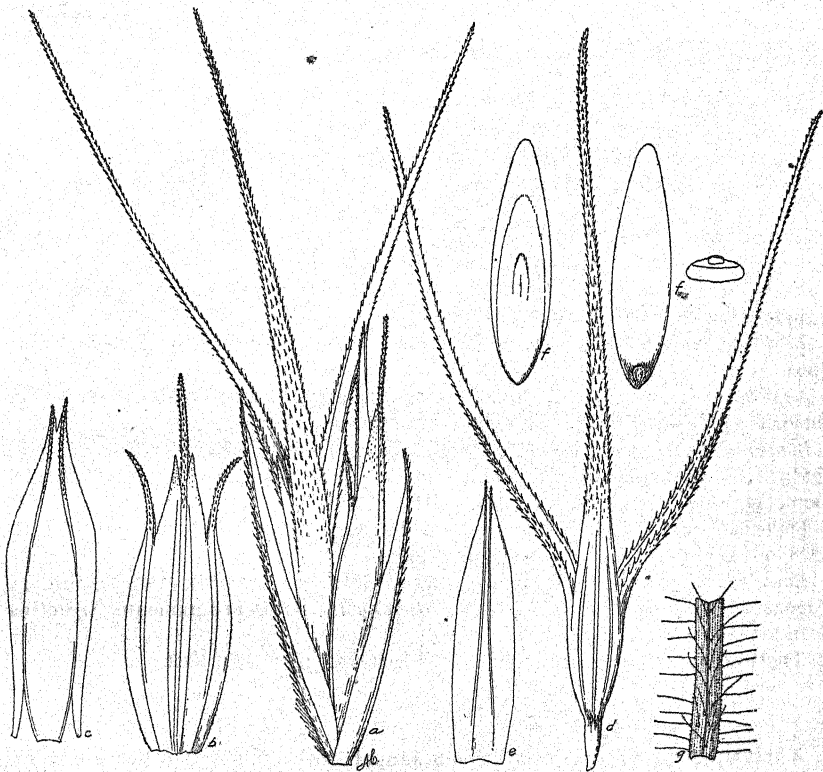


FIG. 48.—*Bouteloua alamosana*. a, Spikelet; b, c, lemma and palea of first floret; d, e, rudimentary lemma and palea of second floret; f, two views and cross-section of caryopsis; g, portion of leaf blade. a-f, Scale 7.5; g, scale 2.5.

lose hairs, especially near the edges, the ligule consisting of a white, ciliate fringe; blades minutely hispid, especially above, and bearing long, papillose hairs at regular intervals on the margins and scattered and less numerous hairs on the surfaces; panicle racemose, 2.5 to 4 cm. long; spikes 3 to 5, 10 to 15 mm. long, very similar to those of *B. texana*, containing 3 to 5 spikelets, these often consisting of one floret and a rudi-

ment, this in the proximal spikelet very much reduced; first glume 5 mm., the second 6 mm. long, scabrous-keeled; lemma 6 to 7 mm. long, 3-awned, the central awn about 1 mm. longer than the lateral, smooth, the awns scabrous; palea 2-awned, smooth, the awns scabrous; rudiment consisting of a staminate floret, the lemma bearing 3 long, scabrous awns, about 11 mm. long, lateral awns about 2 mm. shorter; palea similar to but smaller than that of the perfect floret; caryopsis cylindrical-ovate, 4 mm. long, 0.75 mm. wide, the large scutellum three-fourths the length of the entire caryopsis or more. (FIGURE 48.)

The type specimens furnish most of the knowledge which we have of this species, which grows upon rocky ridges on the Pacific coast of the State of Sonora, Mexico. It is very distinct from any of the other species. It resembles *B. aristidoides* in general habit but is a coarser, more leafy plant, and the spikes are more like those of *B. texana*.

Judging from the material in the National Herbarium this should be found commonly on the Pacific coast of Mexico, south from the State of Sonora. Besides the type specimens there is one collected by Earl Flint in Granada, Nicaragua, in February, 1868, which is at least very close to this species. Confirmatory material from Nicaragua is necessary.

19. *Bouteloua aristidoides* (H. B. K.) Griseb.

Dinebra aristidoides H. B. K. Nov. Gen. & Sp. 1: 171. 1816. The plate of this ^a in a later volume identifies the species without doubt.

Atheropogon aristidoides Roem. & Schult. Syst. Veg. 2: 415. 1817. Based upon *Dinebra aristidoides* H. B. K. See also Spreng. Syst. Veg. 1: 293. 1825; Fourn. Mex. Pl. 2: 139. 1881.

Eutriana aristidoides Trin. Gram. Unif. 242. 1824. Based upon *Atheropogon aristidoides* H. B. K. See also Steud. Syn. Pl. Glum. 1: 216. 1854.

Dineba hirsuta Presl, Rel. Haenk. 1: 292. 1830. The type specimen is in the herbarium of the National Museum at Prague.

Eutriana ? *hirsuta* Kunth, Enum. Pl. 1: 280. 1833. Based upon *Dineba hirsuta* Presl.

Aristida unilateralis Willd.; Steud. Nom. Bot. ed. 2. 1: 132. 1840. A herbarium name of Willdenow published as a synonym of *Eutriana aristidoides*.

Bouteloua aristidoides Griseb. Fl. Brit. W. Ind. 537. 1864. Based on *Dinebra aristidoides* H. B. K. See also U. S. Dept. Agr. Div. Bot. Bull. 12: pl. 35. 1890; U. S. Dept. Agr. Div. Agrost. Bull. 7: 214. f. 196. 1897.

Bouteloua gracilis Hook. ?; Vasey in Wheeler, Rep. U. S. Surv. 100th Merid. 6: 287. 1878, not Lag. 1840. The type is Rothrock's no. 701.

Bouteloua ciliata Griseb. Abh. Ges. Wiss. Göttingen 19: 302. 1879 (Symb. Fl. Argent.). The type specimen, Lorenz & Hieronymus 352, from Juramento, Argentina, is in the Grisebach Herbarium.

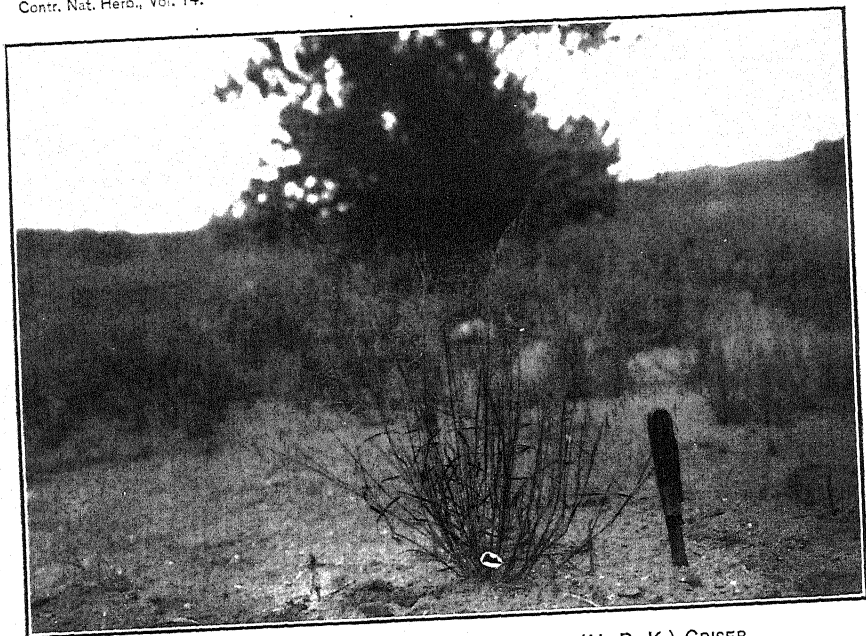
Triathera aristidoides Nash in Small, Fl. Southeast. U. S. 137. 1903.

DESCRIPTION.

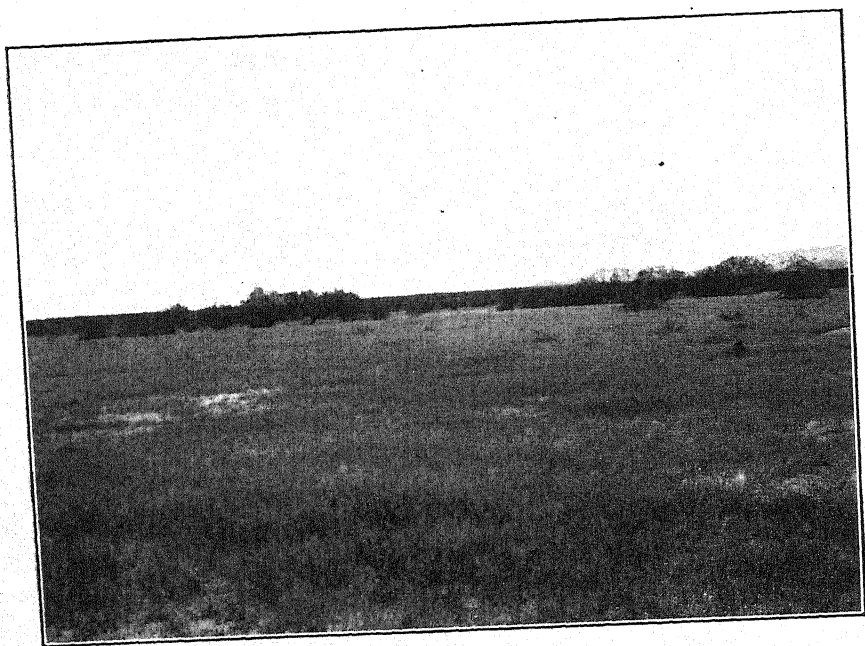
A tufted, erect or decumbent, smooth annual, with upright or geniculate culms, altogether too variable in size to permit of the preparation of lineal descriptions of any value; sheaths loose, especially on branching culms, striate, the lower one-third to one-half the length of the internode, the upper sometimes nearly as long, this depending upon the character of the season; ligule reduced to a membranaceous line or slightly fimbriate, with a few scattered hairs; blades small, few, 2 to 7 cm. long, with a few scattered hairs on the upper surface; panicle variable, 2 to 7 or 8 cm. long, but often in vigorous plants 15 cm. long, bearing normally 10 to 14 spikes, but under

^a Op. cit. 7: pl. 695. 1825.





A. LARGE PLANT OF *BOUTELOUA ARISTIDOIDES* (H. B. K.) GRISEB.



B. SAME SPECIES ON DESERT MESAS.

unfavorable conditions sometimes reduced, in stunted plants, to 2 to 4; spikes pedunculate, the peduncles about 1 mm. long, these, together with the rachis densely white-hairy over the entire surface or only on the angles, the pubescence diminishing in quantity distally to only scattering hairs upon the distal prolongation of the rachis; spikelets 2 to 4, the lowermost more or less aborted, loosely arranged, about 2 mm. apart, consisting of a perfect floret and a rudiment, this reduced or usually absent in the lower spikelet; first glume 1.5 to 2 mm., the second 5 to 6 mm. long, minutely scabrous-keeled, both narrow, acuminate; lemma with three, very short, nearly equal, minutely scabrous awns, pubescent, mostly on the 3 nerves, 6 to 8 mm. long; palea smooth, with two very short, very minutely scabrous awns, about 5 to 6.5 mm. long; rudiment consisting of 3 long, scabrous awns upon a hairy stipe, 1 mm. long, bearing a tuft of longer hairs at its apex, the central awn slightly glumaceous at base and about 2 mm. shorter than the lateral, the whole rudiment being about 7 mm. long; caryopsis cylindrical-oblong, 3 mm. long, 0.4 mm. wide, grooved on the dorsal surface, the scutellum about three-fourths the length of the ventral surface. (PLATE 77, A, B. FIGURE 49.)

The species inhabits the drier desert mesas and foothills from western Texas to the Pacific coast and is as variable as the seasons and conditions in this most variable region. Often it will mature its seed upon a single culm 1 or 2 cm. high, or it may produce plants with 50 culms 70 cm. in height. Often the spikes are not over 3 or 4 mm. in length and produce but a single seed, while in *Palmer 51* some spikes are fully 2.5 cm. in length. The habits of growth of this species particularly fit it for a desert habitat. It is an annual, producing an abundance of seeds which have their special methods of dissemination by burrowing into the ground and thus enable it to persist where less aggressive plants fail. When mature the spike, together with the short, sharp-pointed peduncle, drops off entire. This callus-like peduncle is thickly beset with short, stiff, retrosely arranged hairs, which, together with the awns of the spikelets and the recurved awn-like prolongation of the rachis, assist in the burial of the seed or its adhesion to anything with which it may come in contact.

This is doubtless one of the least valuable of the abundant species of this genus. Usually no grazing is done upon it during the time that it is ripening, and, where very

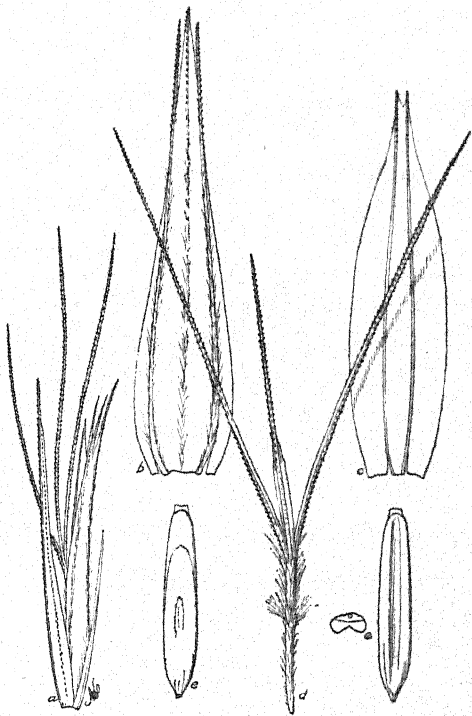


FIG. 49.—*Bouteloua aristidoides*. a, Spikelet; b, c, lemma and palea of first floret; d, rudiment; e, two views and cross section of caryopsis. a, Scale 7.5; b-c, scale 10. From Griffiths 7308.

EXPLANATION OF PLATE 77.—A. A very large plant of *Bouteloua aristidoides* from a favorable depression in desert mesas east of Tucson, Arizona. B. A nearly pure stand of the same upon the desert mesas north of the Santa Rita Mountains of Arizona, in a very favorable season.

plentiful, sheep are removed from it on account of the injury inflicted by the sharp-pointed spikes which work into their feet and disable them. When young, especially before blooming, it is readily grazed by stock, but even then the plants too easily pull up by the roots, the feed therefore being mixed with sand to an annoying extent. In late autumn, after the spikes have fallen off, the grass apparently affords but little nutriment and stock avoid it as much as possible. Associated with it in this country is usually found *Aristida humboldtiana*, which has similar characteristics and which adds to the injurious effects.

HERBARIUM SPECIMENS.

ARIZONA: *Mearns* 1122, San Pedro River near Mexican Boundary; 924, south of Bisbee. *Rothrock* 701, Riley's Well (near Tucson). *Smart* 429, Camp McDowell. *Rusby* 891, Beaver Creek. *Toumey* 802 and in Seymour's Grasses 84, Tucson. *Griffiths* 1523, 3343, Tucson; 1922, Cochise; 1818, Mescal; 1928, Pearce; 3379 and 3418, Santa Rita Forest Reserve. *Jones* 6065, Canaan Ranch. *Wilcox*, Fort Huachuca. *Blumer* 1705, Paradise. *Hitchcock* 3490, 3507, 3510, Tucson; 3665, Patagonia.

CALIFORNIA: *Orcutt*, San Diego.

NEW MEXICO: *Mulford* 1000, Florida Mountains. *Metcalf* 702, Silver City. *Cockerell* 18, Jarilla Junction. *Plank* 43, Socorro. *Wootton* 1053, Las Cruces; 411, Donna Ana County. *Mearns* 2340, Dog Mountains; 924, south of Bisbee. *Hitchcock* 3756, Deming.

TEXAS: *Cockerell* 14, Fort Bliss. *Plank* 8, Llano; 63, El Paso. *Nealley*, Laredo.

MEXICO: *Palmer* 1353, 1354, Soledad, Chihuahua; 162, Guaymas; 1650, Lodiago; 1547, Culiacan; 7, Yaqui River; 177 and 714a, Durango; 859, Carmen Island; 697, Alamos. *Pittier* 474, Tlahualilo, Durango. *Brandege*, Culiacan; 4, San José del Cabo, Lower California. *Schaffner*, San Luis Potosí. *Pringle* 477, Chihuahua; 4592, Tequila. *Parry & Palmer* 941, San Luis Potosí. *Hitchcock* 3638, Nogales; 3594 and 3533, Hermosillo; 3549, Guaymas; 3527 and 3519, Llano. *Rose* 2490, San Juan Capistrano. *Nelson* 6329, Casas Grandes, Chihuahua.

SOUTH AMERICA: *Stuckert* 10624, 12791, 13764, and 20114, Argentina; Kneucker Gram. Exsic. 448; *Kurtz* Herb. Argent. 12670.

20. *Bouteloua pringlei* Scribn.

Bouteloua pringlei Scribn. U. S. Dept. Agr. Div. Agrost. Circ. 30: 4. 1901. Type, *Pringle* 8374, collected in the mountains above Iguala, Guerrero, Mexico, October 24, 1900, in the National Herbarium.

DESCRIPTION.

An erect, caespitose perennial, a meter high, resembling *B. curtipendula* in general appearance and habit; culms erect, simple; nodes and internodes smooth, but sheaths densely papillose-hairy upward, nearly smooth below, rather loose, with a small, densely hairy ligular region; blades long, flat, 5 to 7 mm. wide, more sparingly papillose-hairy; inflorescence racemose, the lower spikes showing a slight tendency to become compound, about 30 cm. long, the spikes arranged bilaterally but so curved or twisted, especially above, as to appear unilateral; spikes variable in size, small above and passing gradually into larger ones below, and finally by indistinct gradations into spike-bearing branches in the lower portion of the incipient panicle; spikelets 4 to 5 mm. long, not pectinate, consisting of a single floret and a rudiment represented by a very short prolongation of the rachilla; first glume nearly 3 mm. long, with hispid keel, the second densely hairy, nearly 4 mm. long, lanceolate, acuminate; lemma ovate, long ciliate hairy on the edges and terminating in three short, equal, hispid awns, about 4 mm. long; palea oblong, terminating in two short, hispid awns; rudiment very short, often difficult to distinguish; caryopsis oblong, 2 mm. long, 0.3

to 0.5 mm. wide, rounded on the back, the scutellum rounded at the apex and covering two-thirds to three-fourths of the ventral surface. (FIGURE 50.)

The only specimens of this species which have been seen are those of the type collection. The species is very closely related to *B. curtispindula*, but is easily distinguished by the felty-pubescent sheaths and the character of the inflorescence.

21. *Bouteloua chondrosioides* (H. B. K.) Griseb.

Dinebra chondrosioides H. B. K. Nov. Gen. & Sp. 1: 173. pl. 53. 1816. The figures and description and a specimen in the Willdenow Herbarium, collected by Humboldt, show conclusively that this is a young plant of what we have long known in this country as *B. havardii*. There is another specimen in the Trinius Herbarium from Humboldt, determined by Kunth in 1836. The figures cited above are faulty in that they do not show the glumes as hairy as they are.

Bouteloua ovata Lag. Gen. & Sp. Nov. 5. 1816. Lagasca's description, "culmo subpentastachyo: spicis ovatis: glumis extus pubescentibus," applies very well to a young specimen of *B. havardii* such as the type of *Dinebra chondrosioides*. This, together with the fact that some of the earlier botanists have suggested that the two names apply to the same species, leads me to this disposition.

Atheropogon chondrosioides Roem. & Schult. Syst. Veg. 2: 416. 1817. Based upon *Dinebra chondrosioides* H. B. K. See also Spreng. Syst. Veg. 1: 293. 1825.

Actinochloa ovata Roem. & Schult. Syst. Veg. 2: 420. 1817. Based on *Bouteloua ovata* Lag.

Eutriana cristata Trin. Gram. Unifl. 241. 1824. Based upon *Atheropogon chondrosioides* Roem. & Schult.

Chondrosium humboldtianum Kunth, Rév. Gram. 1: 93. 1829. Based upon *Dinebra chondrosioides* H. B. K. See also Fourn. Mex. Pl. 2: 136. 1881, where this species is also correctly interpreted. Fournier cites *Virlet* 1412. This number in the herbarium of the Muséum of Paris is exactly comparable with my no. 6732, which is a young specimen of *Bouteloua havardii*.

Schaffner 133, cited by Fournier, in Grisebach's herbarium, is likewise an immature plant of *B. havardii*.

Bouteloua chondrosioides Griseb. in Fourn. Mex. Pl. 2: 136. 1881. This name, presumably based on *Dinebra chondrosioides*, is mentioned as a synonym under *Chondrosium humboldtianum*. Watson^a gives this combination with Bentham as the author.

Bouteloua havardii Vasey in Wats. Proc. Amer. Acad. 18: 179. 1883. Republished in Bull. Torrey Club 11: 6. 1884. The specimen cited in the latter place is *Havard* in 1881, from Limpio Mountains of western Texas. The type specimen in the National Herbarium is numbered 53. See also U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 38. 1890; U. S. Dept. Agr. Div. Agrost. Bull. 7: 216. f. 193. 1897.

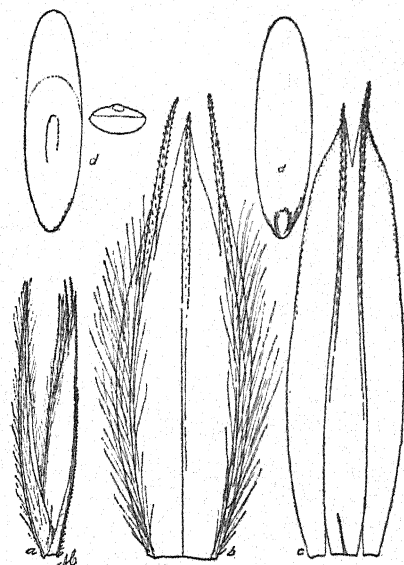


FIG. 50.—*Bouteloua pringlei*. a, Spikelet; b, c, lemma and palea with rudiment attached; d, two views and cross section of caryopsis. a, Scale 7.5; b-d, scale 15. From type specimen.

^aProc. Amer. Acad. 18: 179. 1883.

DESCRIPTION.

A stout, erect, mostly caespitose perennial, with leafy base and comparatively naked culms, striate, loose sheaths, small, sparingly ciliate, pubescent ligules, and slender, flat, rather rigid blades, slightly pubescent beneath; panicle racemose, about 4 cm. long; spikes 4 to 6, densely woolly, 1 to 1.5 cm. long, short-pedicellate from the sharp angles of a zigzag rachis; spikelets consisting of one lower perfect floret and a rudiment, more or less pectinate before anthesis, but this arrangement lost with the development of the long, rigid awns; first glume about 3 mm. long, the second about 4 mm. long, both

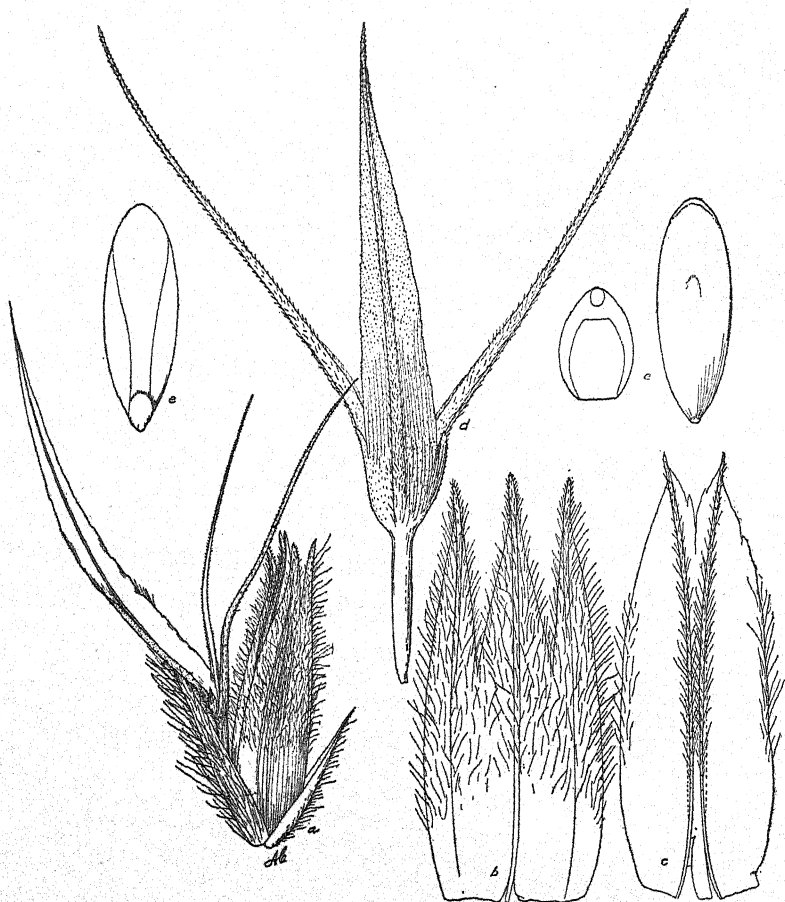


FIG. 51.—*Bouteloua chondrosioides*. a, Spikelet; b, c, lemma and palea of first floret; d, rudimentary second floret; e, two views and cross section of caryopsis. a, Scale 7.5; b-e, scale 10. a-d, From type specimen of *B. havardii*; e, from Griffiths 7266.

densely woolly, acuminate, indistinctly keeled; lemma, about 6 mm. long, densely woolly, terminating in three equal awns; palea about the same length, woolly on the edges, the two nerves terminating in short awns; rudiment consisting of 3 hispid, nearly equal awns, about 7 mm. long, upon a short, naked stipe 1 to 1.5 mm. long, the central awn and often the lateral with glume-like wings; caryopsis oval, about 2.5 mm. long, 0.9 mm. wide, the scutellum covering nearly the whole ventral surface and curving over the sides onto the dorsal surface. (FIGURE 51.)

This species attains its maximum development in the plateau region of Mexico, where there are large areas covered with it to the exclusion of nearly all else. It also

forms a large part of the forage upon limited areas in the foothills in southern Arizona. It is easily recognized by its woolly spikes, but may be confused with *B. eludens*.

There is probably a greater difference between young and mature specimens in this species than in any other of the group. If Kunth's figures are compared with the figures in this text the difference will be easily appreciated. However, my specimens show conclusively that the awns and rudiment develop greatly after anthesis. It is certain that Kunth had immature plants. An examination of the specimens which I am distributing under this name furnish ample proof of the position which is taken here. The plant which Kunth had is also abnormally small. However, this species, in exactly the form described by Kunth, has been seen in abundance in closely grazed areas upon the highlands of Mexico. Upon the highlands of Zacatecas, San Luis Potosí, Aguascalientes, and portions of Jalisco and Oaxaca it is common to find the grass, closely grazed and trampled, forming some semblance of a turf. Under these conditions there is a difference between this form and the common forms of the more arid and stony regions which is comparable to that between the *B. gracilis* of the prairies of the Dakotas and that of the mountains of Arizona. When closely grazed and trampled the culms are short. It was a young plant grown under such conditions that Kunth figured. Conzatti's no. 156 from Oaxaca is a perfect match for the figures mentioned. Portions of Toumey's no. 138, Pringle, "Sandy Plains near Mexican Boundary, Arizona, Aug. 8, 1884," portions of Havard's no. 1, Limpio, Western Texas, July-Sept., 1883, are like the type so far as some of the spikes are concerned. I consider Wilkinson 53, Pringle 410, Lemmon 4635, and 371, Griffiths & Thorner 2, Nealley 414a and 166, typical of *B. havardii* which is the mature stage of the plant. Many of the spikes of Pringle 410 perfectly match the Humboldt specimen.

HERBARIUM SPECIMENS.

ARIZONA: *Hitchcock* 3702, Patagonia. *Griffiths* 1829, Mescal; 3440, Santa Rita Forest Reserve. *Wilcox*, Fort Huachuca. *Griffiths & Thorner* 2, Santa Rita Forest Reserve. *Lemmon*, 371 "S. E. Arizona"; 4635, locality unknown. *Toumey* 800, 138, Tucson. *Parish* 262, Tucson. *Pringle*, near Mexican Boundary.

TEXAS: *Nealley* 166, Presidio County. *Havard* 1, Mesquit Canyon, western Texas; 53, Limpio Mountains.

MEXICO: *Pringle* 410, Chihuahua. *Wilkinson*, Santa Eulalia Plains, Chihuahua. *Mearns* 1897 near Mexican Boundary Monument No. 82. *Palmer* 546, Durango. *Conzatti* 156, Oaxaca. *Rose* 2532, Huejuquilla, Jalisco; 2782, Plateado, Zacatecas.

22. *Bouteloua eludens* sp. nov.

DESCRIPTION.

A tall, erect, caespitose perennial, 20 to 50 cm. high, having a general resemblance in its more diminutive forms to *B. chondrostoides* and in some of its taller, more robust forms to hairy-spiked forms of *B. curtipendula*; culms erect, unbranched; blades rather abundant, narrow, and most radical, flat, with serrate edges, often 15 cm. long and about 1 to 1.5 mm. wide; ligule reduced to a fringe of short, white hairs; inflorescence racemose, 6 to 8 cm. long; spikes 10 to 20, bilaterally arranged on a zigzag axis, but so twisted on the peduncles as to appear unilateral, triangular, about 1 cm. long; spikelets about 5, consisting of a lower staminate, pistillate, or perfect floret, a middle staminate, pistillate, or perfect or even rudimentary floret, and an upper rudiment varying from a simple prolongation of the rachilla, to a trifid-awned structure with two scales or to a well-developed lemma, or sometimes entirely absent; glumes narrow, densely pubescent, the first acuminate, 5 to 6 mm. long, the second very short-awned and about 1 mm. longer; lemma 6 to 7 mm. long, pubescent, trifid, with 3 winged, short awns; lemma of second floret pubescent, about 10 mm. long, with 3 hairy-hispid awns, the central about 1 mm. longer than the lateral and with projec-

tions of the lemma between and outside of the awns; palet of lower floret pubescent above, acuminate, that of the second floret with 2 short awns, both about 6 mm. long; third floret a simple, undivided awn, a rudimentary lemma consisting of 3 long, pubescent, scabrous awns, or a well-developed lemma resembling that of the second floret, but smaller; caryopsis obovate, about 5 mm. long and 1.5 mm. wide, the scutellum covering nearly the entire ventral surface, or only about one-half of it. (PLATES 78, 79, 80, A.)

This species occurs on familiar collecting ground where the most active botanical collectors have worked for years and where the writer collected for about three years before finding it. No specimens of it have been found in any of the herbaria examined. There are literally scores of acres where it forms one-half to three-fourths of the entire vegetation and consequently is, locally, an important economic species.

I first collected the species in the State of Sonora about a mile south of Nogales, Arizona, and subsequently in several situations in northern Sonora and southern Arizona. I have seen or collected it on the slopes of the Cananea Mountains, in the Celero Mountains, where it is most abundant, and in the Santa Rita and Santa Catalina Mountains. It is more likely to occur upon southern exposures, especially in the Santa Rita and the Santa Catalina Mountains, where it may be neglected for the more common and well-known *Bouteloua chondrosioides*. In some situations southeast of Nogales, however, where it grows most luxuriantly, it might be mistaken for a hairy-spiked form of *B. curtipendula*. This in itself indicates a striking variation in the general aspect of the species. As indicated in the illustrations, the floral structure is fully as variable.

The type is Griffiths 7269, collected on southern exposures upon the northern slope of the Santa Rita Mountains, Arizona, September 17, 1904.

23. *Bouteloua megapotamica* (Spreng.) Kuntze.

Pappophorum megapotamicum Spreng. Syst. Veg. 4: Cur. Post. 34. 1827. The type was collected by Sello "Rio Grande," Brazil.

Eutriana multiseta Nees, Agrost. Bras. 413. 1829. This was described from a specimen in the Berlin Herbarium collected by Sello at Montevideo. This specimen and a duplicate in the Trinius Herbarium have been examined. See also Kunth, R v. Gram. 2: 449. pl. 138. 1829.

Pappophorum eutrianoides Trin.; Nees, Agrost. Bras. 414. 1829. Mentioned as a synonym under *Eutriana multiseta*.

Bouteloua multiseta Griseb. Abh. Ges. Wiss. G ttingen 19: 303. 1879 (Symb. Fl. Argent.). Based upon *Eutriana multiseta* Nees.

Bouteloua megapotamica Kuntze, Rev. Gen. Pl. 3²: 341. 1893. Based upon *Pappophorum megapotamicum* Spreng.

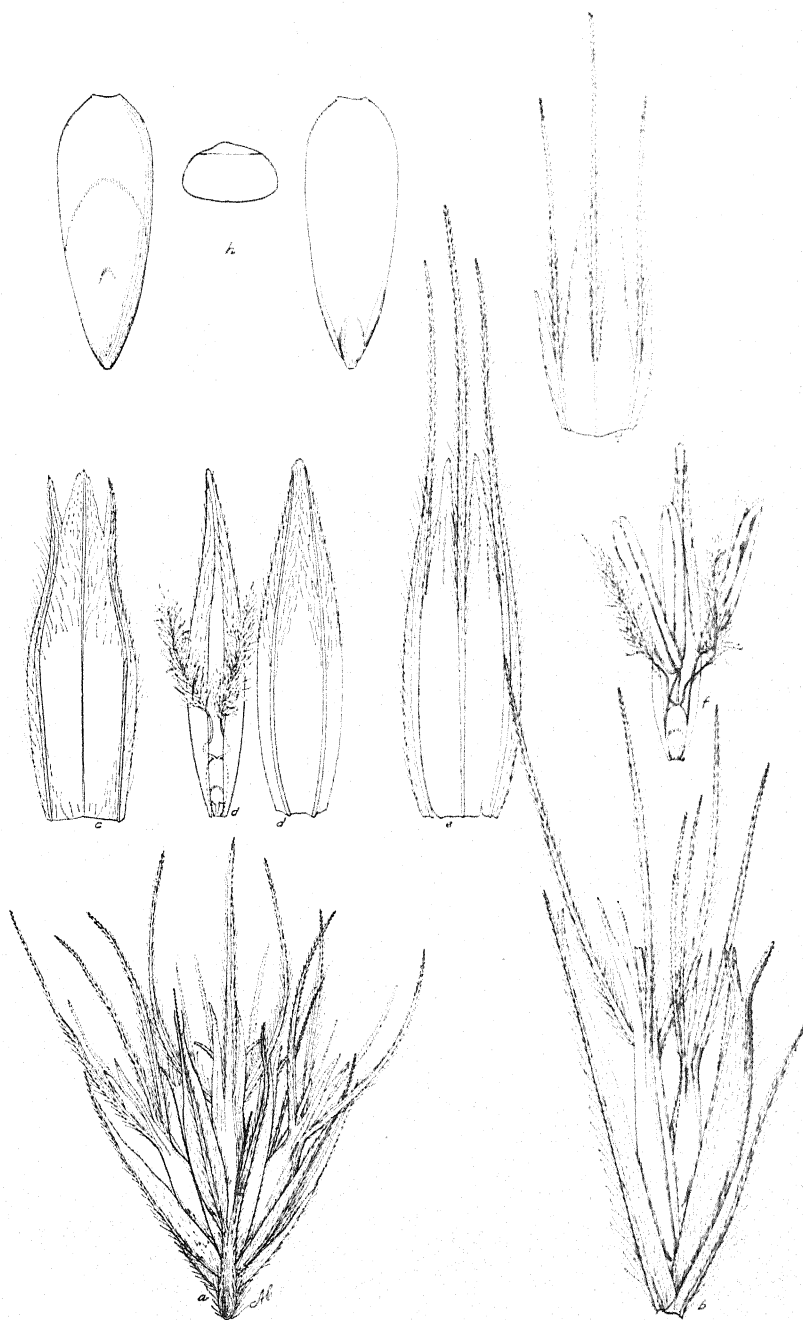
DESCRIPTION.

A caespitose, erect or ascending, strongly stoloniferous perennial; culms about 20 cm. high, erect or geniculate at base, not branched; sheaths close, striate, smooth; blades rather rigid, abundant below, and often 10 cm. long, but short above, inconspicuously hairy especially on the lower surface, the edges hispid; ligule consisting of

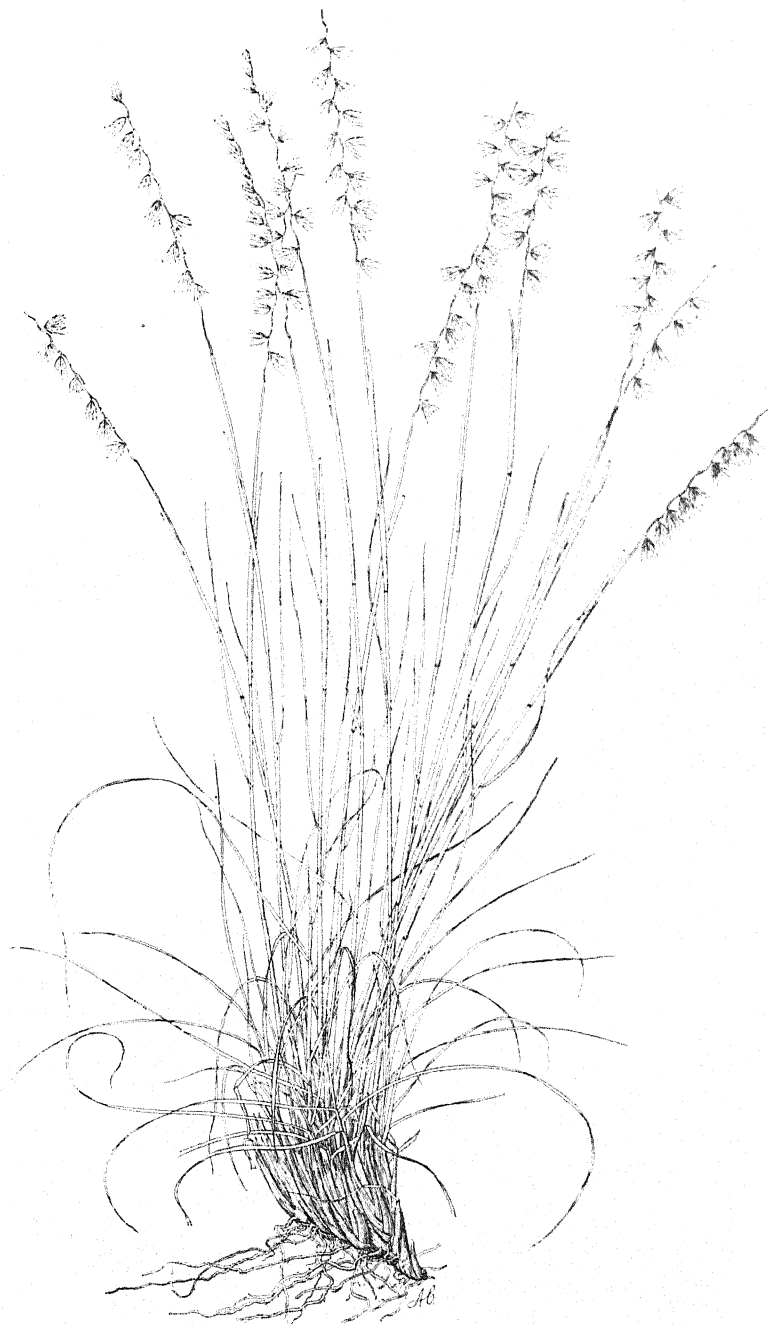
EXPLANATION OF PLATE 78.—a, Spike of *Bouteloua cludens*; b, spikelet; c, lemma of first floret; d, two views of palet of same, one showing pistillate flower; e and f, lemma and palet with perfect flower of second floret; g, rudimentary lemma of third floret; h, two views and cross section of caryopsis. a-f, Scale 5; g, scale 7.5; h, scale 15. From type specimen.

EXPLANATION OF PLATE 79.—From type specimen of *Bouteloua cludens* and photograph taken in Santa Catalina Mountains, Arizona. (5 x 7 No. 3076 Farm Management, U. S. Dept. Agr.)

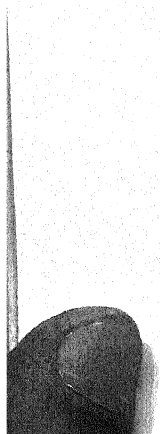
EXPLANATION OF PLATE 80.—View showing the strong tufty character of *Bouteloua cludens*, on southern exposures in Sabino Canyon, Santa Catalina Mountains, Arizona, in the latter part of September. B. *Bouteloua texana* from the vicinity of San Antonio, Texas, where this grass is of minor importance, being usually crowded by ranker species. Farther north, in the vicinity of San Angelo, it grows more nearly pure.



BOUTELOUA ELUDENS GRIFFITHS.



BOUTELOUA ELUDENS GRIFFITHS.



a ring of numerous long, white hairs; spikelets about 5 to 10, not pectinate, consisting of 1 floret and a rudiment; glumes hispid and hairy-tufted at base, awned, the first 6 mm., the second 10 mm. long, the latter having an abrupt constriction above, the apex continued into two acuminate, awn-like teeth, 0.5 to 1 mm. long, on each side of the central awn; lemma 11 to 12 mm. long including awns, smooth, shining, and bone-like on the back, with 3 hispid, spreading awns about 5 mm. long, the lateral awns nearly equal to the central; palet deeply sulcate on the back and involute on the

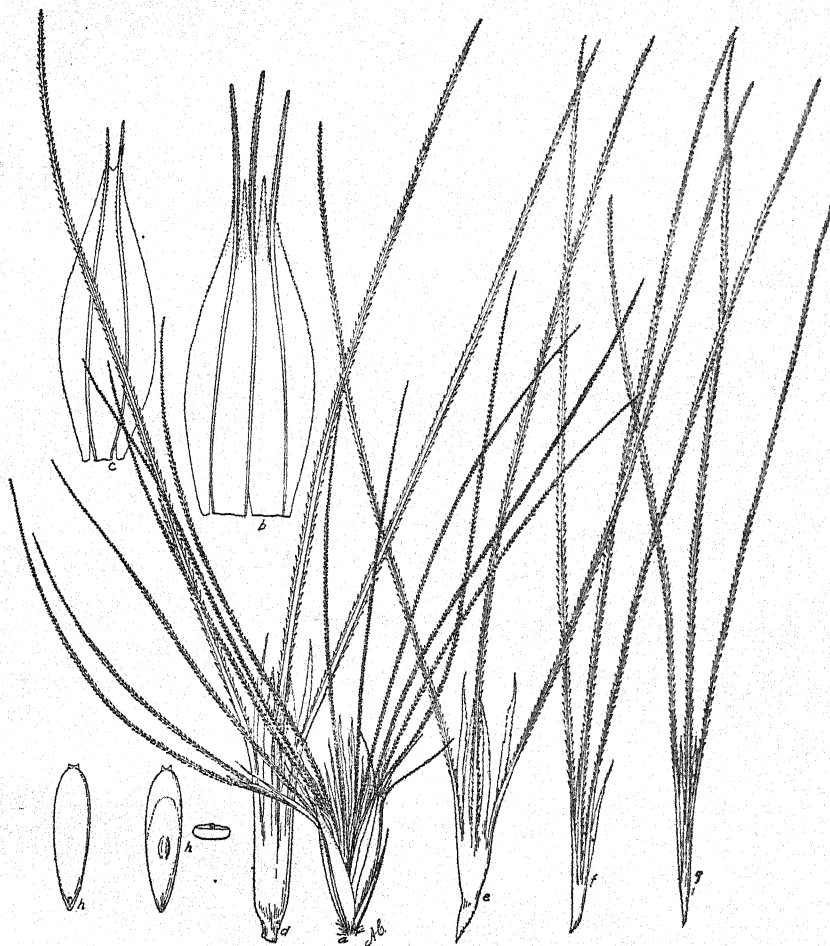


FIG. 52.—*Bouteloua megapotamica*. a, Spikelet; b, c, lemma and palet of first floret; d-g, rudimentary second, third, fourth, and fifth florets; h, two views and cross section of caryopsis. a, Scale 2.5; b-h, scale 5. From *Arechavaleta*, Montevideo.

edges, 2-awned, 8 to 9 mm. long; rudiment consisting of 2 or 3 aborted florets appearing like a cluster of 9 to 12 hispid awns of various degrees of rigidity, interspersed with delicate narrow scales a fourth as long or less; caryopsis cylindrical-obovate, 2 to 2.5 mm. long, the scutellum covering about two-thirds of the ventral surface. (FIGURE 52.)

Stuckert's no. 27, Kneucker's Gram. Exs. 376, and *Arechavaleta* from Montevideo, are typical. The latter shows the stoloniferous character beautifully.

24. *Bouteloua texana* S. Wats.

Bouteloua (Polyodon) texana S. Wats. Proc. Amer. Acad. **13**: 196. 1883. The first specimen cited, *Berlandier* 1535, which I accept as the type, I have been unable to find in the Gray Herbarium. Duplicates of *Hall* 771 and *Wright* 752, which are cited by Watson, are in the National Herbarium. See also U. S. Dept. Agr. Div. Agrost. Bull. **7**: 215. *f.* 197. 1898.

Polyodon texanus Nash in Small, Fl. Southeast. U. S. **138**. 1903.

DESCRIPTION.

An erect, caespitose perennial, 20 to 30 cm. high, usually growing in scattering bunches among other grasses, seldom occupying areas exclusively; culms simple, erect; sheaths rather close, smooth, striate, with a small ligule bearing a few scattered hairs or a ciliate fringe; blades narrow, involute, about 10 cm. long, sparingly pubescent with long, papillose hairs on the edges and especially on the upper surface, the hairs less conspicuous below; inflorescence racemose, 4 to 5 cm. long; spikes 6 to 8, about 1 cm. long, on short, pubescent peduncles 1 mm. long, easily separable and dropping off entire; spikelets not pectinate, crowded, consisting of a lower fertile floret and 2 upper rudiments, or often the entire spikelet rudimentary; glumes unequal, lanceolate, acuminate, hairy, the first 3 to 4 mm., the second about 6 mm. long, short-awned; lemma about 6 mm. long over all, sparingly hairy on the nerves, bearing 3 equal, hispid awns; palet 4 to 5 mm. long; ovate, acuminate or with 2 very short awns; lower rudiment of 3 equal, hispid awns about 7 mm. long, united at their bases by rudimentary glumes, and having a rudimentary, cleft palet 2 to 3 mm. long, the upper rudiment of the same nature but smaller in all its parts and usually with no palet; caryopsis about 2 mm. long, 0.6 mm. wide, flat on the dorsal surface, the scutellum covering about seven-eighths of the entire ventral surface. (PLATE 80, B, facing p. 402. FIGURE 53:)

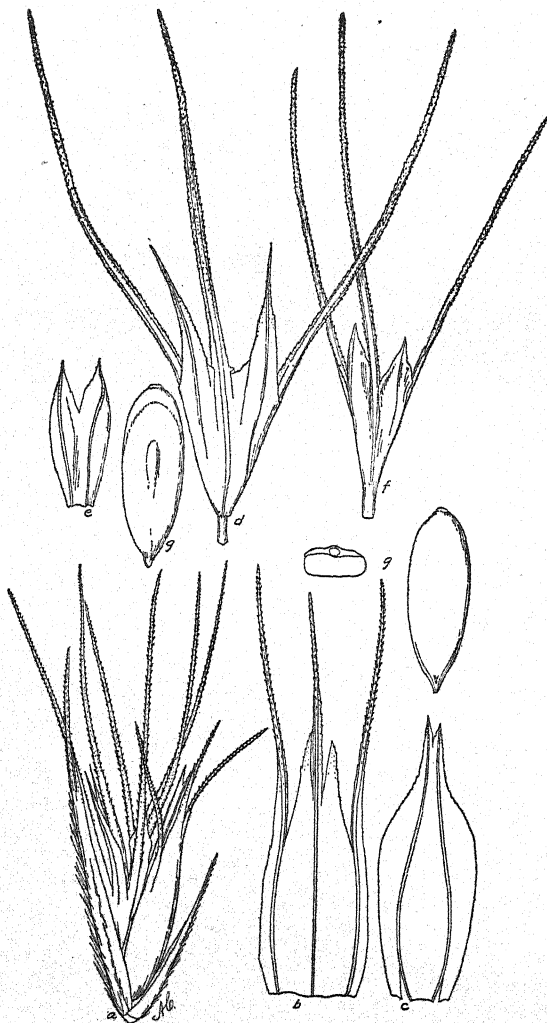


FIG. 53.—*Bouteloua texana*. *a*, Spikelet; *b*, *c*, lemma and palet of first floret; *d*, *e*, rudimentary lemma and palet of second floret; *f*, rudimentary third floret; *g*, two views and cross section of caryopsis. *a*, Scale 7.5; *b*-*g*, scale 10. From Griffiths 6370.

second about 6 mm. long, short-awned; lemma about 6 mm. long over all, sparingly hairy on the nerves, bearing 3 equal, hispid awns; palet 4 to 5 mm. long; ovate, acuminate or with 2 very short awns; lower rudiment of 3 equal, hispid awns about 7 mm. long, united at their bases by rudimentary glumes, and having a rudimentary, cleft palet 2 to 3 mm. long, the upper rudiment of the same nature but smaller in all its parts and usually with no palet; caryopsis about 2 mm. long, 0.6 mm. wide, flat on the dorsal surface, the scutellum covering about seven-eighths of the entire ventral surface. (PLATE 80, B, facing p. 402. FIGURE 53:)

On account of the abundance of root leaves and its bunched nature, this is a rather good forage grass. It does not appear to be able, however, to compete successfully enough with other species to make it of any great importance. The species is common on the southern plains and in the Rio Grande region and is rather important in the vicinity of San Angelo, Texas.

Pringle's no. 9018, distributed as *B. bromoides* Lag., Nealley 17, Heller 1485, Tracy 8105, and Reverchon 1135 are representative of the species.

HERBARIUM SPECIMENS.

TEXAS: Drummond 374. Ball 1110, Chillicothe. Wright 75, Dallas. Letterman, Dallas, August, 1882. Hall 771, Houston. Nealley in 1889; 17, Houston. Reverchon 1155, 4215 and 522, Dallas. Heller 1485, Nueces County. Piper, Kingsville. Warburton, Terrell. Tracy 8861 and 8889, Corpus Christi; 8878, Kingsville; 8105, Abilene. Havard, Eagle Pass. Jermy, San Antonio. Smith, Kerrville and San Diego. Bray 329, Llano; 296, Fredericksburg. Bush 244, Houston; 176, Columbia. Plank 28, Burnet.

MEXICO: Pringle 9018, Diaz, Coahuila.

25. *Bouteloua lophostachya* Griseb.

Bouteloua lophostachya Griseb. Abh. Ges. Wiss. Göttingen 19: 302. 1879 (Symb. Fl. Argent.). The type (Hieronymus's no. 971 from Argentina) in the Grisebach Herbarium, has been examined.

Bouteloua nana Griseb. Abh. Ges. Wiss. Göttingen 19: 303. 1879 (Symb. Fl. Argent.). The type in the Grisebach Herbarium (Hieronymus's no. 721, Guazapampa, Argentina) is unquestionably a depauperate form of *B. lophostachya*. *Bouteloua nana* is also a younger plant but the panicle and the floral and habit characteristics are in every respect identical with those of *Hieronymus* 971.

DESCRIPTION.

A caespitose, harsh, rigid perennial, with freely branching stems and short, stout rootstalks; sheaths striate, short but completely covering the lower internodes; blades rigid, divaricate, harsh, keeled, sharply cuspidate-pointed, 2 to 4 cm. long, abundant below but few above; panicle with 15 to 30 spikes scattered along the main axis, 5 to 10 cm. long, occasionally 2 or 3 spikes together; spikes loosely and indistinctly pectinate, 1 to 3 cm. long; spikelets 15 to 20, consisting of a lower perfect floret, with 2 to 4 rudiments above; glumes very slightly scabrous-keeled and short-awned, the first slightly shorter than the second, about 2 mm. long; lemma pubescent, 3 to 3.5 mm. long, 3-awned, the central awn 2 or more times longer than the lateral; palet obovate, 2-nerved, awnless, about 1.5 mm. long; rudiment consisting of 4 or even 5 well-developed 3-awned scales resembling the lemma but diminishing

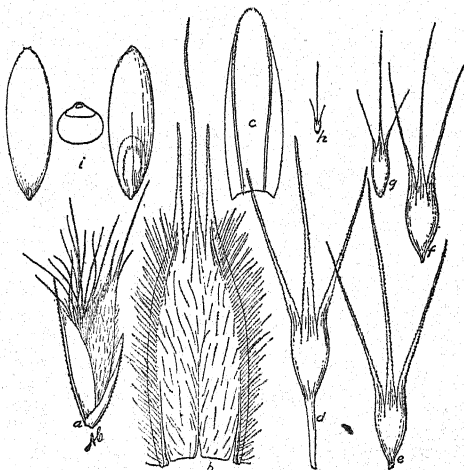


FIG. 54.—*Bouteloua lophostachya*. a, Spikelet; b, c, lemma and palet of first floret; d-h, rudimentary second, third, fourth, fifth, and sixth florets; i, two views and cross section of caryopsis. a, Scale 10; b-i, scale 15. From Kurtz 12687.

in size upward, the last sometimes faced by a small 1-awned scale, the whole so congested as to appear like a bunch of awns, and borne upon a short, naked stipe about 1 mm. long; caryopsis 1.25 mm. long, ovate, flattened on the back, the very small scutellum covering only one-fourth or one-fifth of the ventral surface. (FIGURE 54.)

In general appearance, especially as to inflorescence this species resembles *Lep- tochloa*, but the floral characters are those of *Bouteloua*. The basal portion of the plant resembles that of *Muhlenbergia pungens* Thurb.

HERBARIUM SPECIMENS.

SOUTH AMERICA: *Stuckert* 10277a, in Herb. Argent.; 694, in Kneucker's Gram. Exs. from Argentina. *Elliott* 510, Chile. *Benivati* 12687 in Kurtz, Herb. Argent.

26. *Bouteloua acuminata* (Fourn.).

Atheropogon acuminatus Fourn. Mex. Pl. 2: 139. 1881. The specimens cited, *Liebmann* 583, from Mirador, and *Liebmann* 584, from Potrero de Consoquitla, Mexico, have not been examined. My knowledge of the species is based upon Palmer's no. 1655, concerning the identity of which there appears to be no doubt.

DESCRIPTION.

A stout, erect, smooth, caespitose perennial, resembling *B. curtipendula* in habit and general appearance; culms erect, comparatively stout, about 50 cm. high, leafy to the top, mostly unbranched; sheaths striate, close; blades broad, flat, often 5 mm. wide and 25 cm. long, striate, smooth with serrate edge, and conspicuous, long, dusky, papillose hairs on the upper surface at the base, the ligular membrane with a few scattered hairs of the same nature; panicle racemose, often 25 cm. long; spikes numerous, 30 to 60, distinctly bilateral but the peduncles so curved as to appear unilateral toward maturity; spikelets 6 to 15, loosely and indistinctly or not at all pectinate, consisting of 1 floret and a rudiment; glumes hispid, keeled, the first acuminate, about 2 mm. long, the second short-awned, about 3 mm. long; lemma minutely pubescent, shortly 3-aristate, the central awn 0.5 mm. or less longer than the lateral, about 4 mm. long; palet, acuminate, smooth, about 2.5 mm. long; rudiment reduced to a single, hispid, delicate awn, about 1.5 mm. long; caryopsis not seen. (FIGURE 55.)

FIG. 55.—*Bouteloua acuminata*. a, Spikelet; b, c, lemma and palet of first floret; d, rudiment. a, Scale 7.5; b-d, scale 10. From Palmer 1655.

In general habit this very closely resembles *B. curtipendula*, but the spikes are very different, although exactly the same in arrangement. They are smaller and apparently more numerous. Indeed, one might describe the species as *B. curtipendula* with small delicate spikes of rather loosely arranged spikelets, only a fourth the size of those of that well-known species.

Palmer's 1655, cited above, of which there are two sheets in the National Herbarium, is from Lodiogo, Sonora, Mexico, collected October 9 to 15, 1891. It is said to grow in large bunches on the mountain sides.

27. *Bouteloua vaneedeni* Pilger.

Bouteloua vaneedeni Pilger in Urban, Symb. Antill. 6: 2. 1909; see also Boldingh, Recueil Trav. Bot. Néerland. 6: 7. 1909.

DESCRIPTION.

An erect, caespitose perennial, 30 to 40 cm. high; sheaths smooth, striate, close; blades narrow, involute, 6 to 10 cm. long, with a very small ligular ring of white hairs; inflorescence racemose, about 12 to 15 cm. long; spikes small, 4 to 5 mm. long, and only about 1 mm. wide, numerous, about 30; spikelets 2 to 4, in specimens before me only the distal one fully developed, the proximal ones 1-flowered, the distal one with a second floret in the form of a trifold rudiment, the lateral awns very short; glumes smooth, strongly nerved, the first 3 mm., the second 4 mm. long, scarcely awned; lemma smooth, 4 mm. long, bearing awns less than 1 mm. long; palea about the length of its lemma, bearing very short awns. (FIGURE 56.)

I am under obligations to both Doctors Pilger and Boldingh for specimens of this interesting species, collected by the latter (no. 3512 B) in the island of Anguilla, Leeward Islands.

In general aspect it appears to be very similar to *B. curtipendula*, while in other respects it even more closely resembles *B. uniflora*. In detail of the spike it bridges over three genera as here limited. The species is interesting in that there are one to three aborted, 1-flowered spikelets below and only one well-developed distal spikelet in which the second floret is the normal trifold awn, with, however, the lateral awns so short as to be scarcely visible. The type affords all the knowledge we have concerning this species and that specimen is immature. It is possible that mature material will necessitate a different disposition of the species.

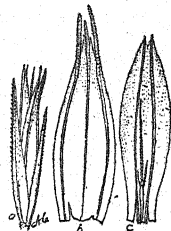


FIG. 56.—*Bouteloua vaneedeni*. a, Spikelet; b, c, lemma and palea with rudiment attached. a, Scale 5; b, c, scale 7.5. From type specimen.

28. *Bouteloua americana* (L.) Scribn.

Aristida americana L. Amoen. Acad. 5: 393. 1759; Syst. Nat. ed. 10. 2: 879. 1759. This name has been misapplied by recent authors because of a misstatement by Munro^a concerning its identity. Munro says that *A. americana* "is called *A. dispersa* by Trin.", and that "Kunth has misplaced the Linnæan synonym in *Euriana juncifolia*." Munro, however, was in error, as is easily shown by an examination of the Linnæan plant (see under *Bouteloua americana* Scribn.); Swartz, Obs. Bot. 41. pl. 2. f. 2. 1791. The type, in the Linnæan Herbarium, is a specimen from Jamaica, collected by Patrick Browne.

Triathera americana Desv. Nouv. Bull. Soc. Philom. Paris 2: 188. 1810. Based upon *Aristida americana* L. See also Roem. & Schult. Syst. Veg. 2: 421. 1817.

Dineba americana Beauv. Ess. Agrost. 98, 160. pl. 16. f. 1-3. 1812. Based upon *Aristida americana* L.

Heterosteca americana Desv. Journ. de Bot. 1: 68. 1813. Based upon *Aristida americana* Swartz.

Bouteloua litigiosa Lag. Gen. & Sp. Nov. 5. 1816. Based upon *Aristida americana* L. *Aristida furcata* Poit.; Roem. & Schult. Syst. Veg. 2: 711. 1817. A herbarium name published as a synonym of *Dineba americana* Beauv.

Euriana juncea Trin. Gram. Unif. 238. 1824. The specimen in the Trinius Herbarium, collected by Poiteau in Haiti, probably is the *Aristida americana* of Linnæus.

^a Proc. Linn. Soc. Bot. 6: 49. 1862.

I can not, however, from the insufficient fragment before me be certain about it. The leaves are shorter and rather more rigid than in that species.

Eutriana bromoides Trin. Gram. Unifl. 241. 1824, not Kunth 1833. It is more than probable that the species to which Trinius applied this name is *B. americana*, although the first synonym cited is *Atheropogon bromoides* Roem. & Schult. The other two synonyms are *Aristida americana* L. and *Bouteloua litigiosa* Lag., and the plant described is from the West Indies. Kunth^a has in effect expressed the same view.

Bouteloua elatior Griseb. Fl. Brit. W. Ind. 537. 1864. A portion of the type, *Wullschlagel* 619 and 660, Antigua, in the Grisebach Herbarium, and a photograph are before me. It is typical of *Aristida americana* L.

Atheropogon americanus Fourn. Mex. Pl. 2: 139. 1881. Based upon *Aristida americana* L.

Bouteloua triathera Benth. Journ. Linn. Soc. Bot. 19: 104. 1881. Presumably based on *Triathera americana* Desv.

Bouteloua americana Scribn. Proc. Acad. Phila. 1891: 306. 1891. Scribner bases this name on "*Aristida americana* Sw. Obs. 41. t. [2.] f. 2. (1791)", on the supposition that this was distinct from *A. americana* L., citing Munro's statement,^b that the Linnean *A. americana* was a true *Aristida* and the species named *Aristida dispersa* by Trinius. But, as has been shown, Linnaeus's type specimen is a *Bouteloua*. Swartz does not give this as one of his own species, but gives a reference that leads to Linnaeus's species. Swartz's illustration shows that he correctly interpreted the species. Hence Scribner's name is, in the last analysis, based on *Aristida americana* L.

DESCRIPTION.

A spreading, ascending, or erect, smooth annual; flowering culms mostly erect, freely branched, 20 to 30 cm. high; sheaths striate, smooth, short, close; blades narrow, involute, acuminate, bearing numerous papillose hairs on the edges toward the base, there merging into the very narrow ligular ring; spikes about 2 cm. long, very lax, 3 to 6 or 7; spikelets 5 to 7, about 3 mm. apart, not pectinate but loose, and lying at a narrow angle with the rachis; glumes pronouncedly keeled and strongly hispid, rather abruptly acuminate, the first about 3 mm., the second about 4 mm. long; lemma smooth, shining, and bone-like on the back, 3-awned, the lateral awns less than 1 mm. long, the central projecting about 2 mm. farther; palet 2-nerved, with 2 short awns, nearly as long as its lemma; rudiment consisting of a modified lemma of 3 awns about 9 mm. long, united into a hard small scale at the base and faced by a small 2-nerved rudimentary palet; caryopsis not seen. (FIGURE 57.)

The group comprising *Bouteloua americana* and the five species here following is a very difficult one and a great many names have been applied to the different species owing to a difference of opinion among authors as to generic and specific limitations and to the disregard of the principle of priority as well as to a misunderstanding or neglect of the earlier descriptions.

Bouteloua radicata as interpreted here is fairly well marked off. It is a large, robust, almost woody based plant with wide, strongly papillose-hairy leaves. *Bouteloua repens* as here interpreted is not so common as has been supposed. It is easily recognized by its glaucous aspect and by its lack of papillose hairs. The species appears to be confined to the Pacific coast region of central and southern Mexico.

Bouteloua americana also is well characterized by its narrow spikes and annual habit.

It is *B. filiformis* and *B. heterostega* that present the greatest difficulties. They are very difficult to segregate, but that is simply another way of acknowledging that we do not know the species well enough.

^a Enum. Pl. 1: 281. 1833, under *E. bromoides*.

^b See above under *Aristida americana* L.

In southern Arizona there is a plant which has heretofore passed for *B. bromoides*, so called. It is erect and has comparatively delicate stems and leaves. In southern Texas, where the soil is more fertile, precipitation more abundant, and shade of shrubbery a more important factor, it has a lighter green color and the culms are more inclined to become geniculate and often are decidedly so. In portions of the Mexican highland, where I judge the conditions are similar to those of Texas, upon the ocean slopes and apparently in portions of South and Central America the characteristics of the Texas form are accentuated and the culms are decidedly geniculate and much branched. In the West Indian islands the plant becomes still more modified into an exceedingly variable form which is often depauperate, prostrate, or even slightly stoloniferous. In the entire series I have as yet found no constant floral distinctions except that the West Indian plants often have greatly reduced spikes and prominently modified spikelets, which, however, always have typical ones mixed with them.

As stated above the Arizona-Texas plant has in the past been referred to *B. bromoides*. It extends in a typical form throughout the Mexican highland at least as far as the Isthmus of Tehuantepec. The geniculate Mexican form received the specific name *filiformis* from Fournier and the West Indian plant was called *Heterosteca juncifolia* by Desvaux. For the present it seems wise to recognize Desvaux's species, although unfortunately his name can not be used, and to include under that of Fournier the two forms of the Mexican highland, one of which reaches Arizona and is somewhat modified in Texas. Should it appear wise in the future to separate these two forms the erect one so typical of southern Arizona and the highland of Mexico will have to receive a new name.

HERBARIUM SPECIMENS.

WEST INDIES: *Wright* 3816, Cuba. *Ricksecker* 78, St. Croix. *Broadway*, Tempe, St. George. *Hart* 559, Gordon Town, Jamaica. *Eggers* 687, St. Thomas; 5650, Scarborough, Tabago Island.

PANAMA: *Hitchcock* 8409.

There are two specimens, *Elliot* 188, Granada, and *Duss* 3160, Guadeloupe, which appear a little different in habit. They are mainly larger, ranker plants with even laxer spikes and with slightly shorter awns.^a

29. *Bouteloua repens* (H. B. K.) Scribn. & Merr.

Dinebra repens H. B. K. Nov. Gen. & Sp. 1: 172. pl. 52. 1816. "Crescit ad littora Oceani Pacifici prope Acapulco." My interpretation of this is based upon the figures and descriptions.

? *Bouteloua bromoides* Lag. Gen. & Sp. Nov. 5. 1816. Lagasca says the plant is from Acapulco, which is the only reason for referring it to *B. repens*. He also says it is an annual, but this would be an easy mistake to make. A later specimen from

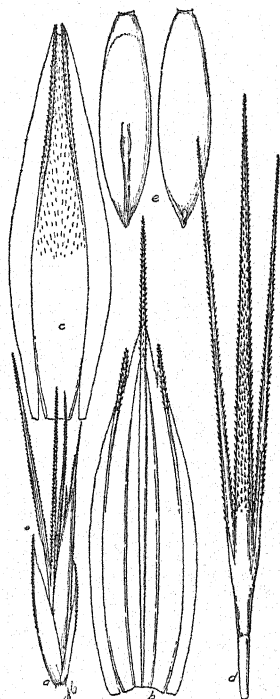


FIG. 57.—*Bouteloua americana*. a, Spikelet; b, c, lemma and palea of first floret; d, rudiment; e, f, two views of caryopsis. a, Scale 5; b-f, scale 10. From *Wright* 3816.

^a Only the specimens in the National Herbarium are before me, as the last work on this group is done; consequently, citation of specimens can not be as ample as it otherwise might be.

Lagasca in the herbarium at Munich and one from the herbarium of the Botanical Garden at Madrid, bearing this name in Lagasca's hand, spikelets of which are before me, possibly should go with *B. filiformis*. It seems impossible to identify it. It has been commonly assumed that *Bouteloua bromoides* Lag. was the same species as that named *Dinebra bromoides* by Kunth, but Lagasca does not mention Kunth's species and his description does not apply to it.

? *Actinochloa bromoides* Roem. & Schult. Syst. Veg. 2:420. 1817. Based upon *Bouteloua bromoides* Lag.

Atheropogon repens Roem. & Schult. Syst. Veg. 2:416. 1817. Based upon *Dinebra repens*. See also Spreng. Syst. Veg. 1:293. 1825. Fournier^a uses this name, but it is very certain that the specimens he cites under it do not belong here.

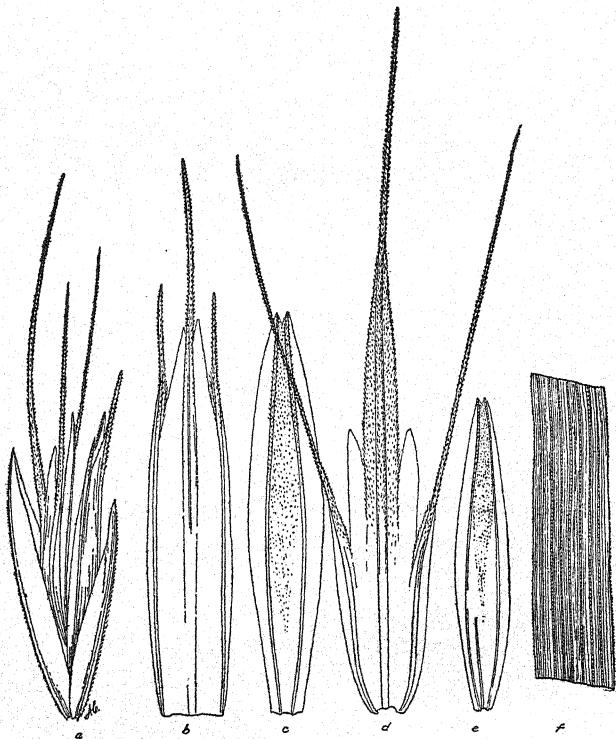


FIG. 58.—*Bouteloua repens*. *a*, Spikelet; *b*, *c*, lemma and palea of first floret; *d*, *e*, lemma and palea of second floret (rudiment attached to palea); *f*, portion of leaf blade. *a*, Scale 5; *b*–*e*, scale 7.5; *f*, scale 2.5. From Hitchcock 7080.

Bouteloua repens Scribn. & Merr. U. S. Dept. Agr. Div. Agrost. Bull. 24:26. 1891. Based upon *Dinebra repens*. The former is the first correct combination which has been found, although the name was applied to a different species.

DESCRIPTION.

A smooth, glaucous-gray, leafy, stoloniferous, perennial, with erect or ascending and geniculate culms, 50 to 60 cm. high; sheaths striate, smooth, lax on branching culms, close on simple ones, the ligule bearing a few short, white hairs; blades broad, flat or the upper more commonly involute in drying, about 10 cm. long, and 4 mm. wide, conspicuously striate, hispid on the edges; panicle racemose, 10 cm. or more

^a Mex. Pl. 2:140. 1881.

long, the basal portion often included in the sheath at anthesis; strikingly colored, with its purple glumes, green lemmas and cinnabar-colored anthers; spikes about 12, rather lax, flattened, 2.5 cm. long including the awns; spikelets 2-flowered with an additional rudiment consisting of a short, naked, awn-like projection beyond the palea of the second floret, and usually included in the fold of the palea; lower floret hermaphrodite, the second staminate or neuter; glumes sharply and hispidly keeled, acuminate but not awned, the second about 7 mm. in length, the first a trifle shorter; lemma of lower floret about 8 mm. long, with 3 short awns, the lateral awns 2 mm. shorter than the central; lemma of upper floret 12 mm. long, long-awned, the awns about the same relative length as in the lower floret, prominently scabrous; palea long, narrow, with 2 very short awns, plicate; caryopsis not seen. (FIGURE 58.)

No authentic material of this has been examined. Several of the older authors have listed it from Acapulco, but referred to it various forms of *B. filiformis*. It is distinguished from other species of the group by its large, stout, glaucous aspect and by its lack of papillose hairs on the edges of the leaves.^a

Hitchcock's no. 7080, from Manzanillo, Mexico, is the only collection that I am able to refer to this species. It grows in large patches so close to the sea that the spray reaches it at high tide.

30. *Bouteloua radicata* (Fourn.).

Dinebra bromoides H. B. K. Nov. Gen. & Sp. 1: 172. pl. 51. 1816, not *Bouteloua bromoides* Lag. 1816. My interpretation of this is based upon the figures and description cited. There has been some confusion concerning this species, due mainly to the misinterpretation of this and also of *D. repens* H. B. K. See also Presl, Rel. Haenk. 1: 292. 1830. The Haenke specimen in the herbarium of the German University of Prague shows that the species was correctly interpreted by Presl.

Atheropogon bromoides Roem. & Schult. Syst. Veg. 2: 415. 1817. Based upon *Dinebra bromoides* H. B. K. See also Spreng. Syst. Veg. 1: 293. 1825. Sprengel cites *Aristida americana* Swartz as a synonym, but that name does not belong to this species. It appears that Fournier^b misinterpreted this. He credits the species to Roemer and Schultes and cites *Dinebra bromoides* H. B. K. as a synonym. According to my interpretation, however, the specimens which he cites belong to *A. filiformis*. *Galeotti* 5704 in the U. S. National Herbarium and the herbarium of the Botanical Garden of Brussels, a Karwinski specimen in the St. Petersburg Botanical Garden, and *Schaffner* 125 in the Willdenow Herbarium, all belong to *A. filiformis*. The same is true of *Botteri* 107 and *Liebmann* 575. A sheet of the last mentioned specimen in the National Herbarium is from the herbarium of the Muséum at Paris and is said to have been determined by Fournier.

Eutriana bromoides Kunth, Rév. Gram. 1: 95. 1829, not Trinius, 1824. Based upon *Dinebra bromoides* H. B. K. See also Kunth, Enum. Pl. 1: 281. 1833 and op. cit. 2: 234. pl. 17. f. 4. 1835; also Steud. Syn. Pl. Glum. 1: 216. 1854.^c

Nestlera festucaeformis Willd.; Steud. Nom. Bot. ed. 2. 2: 192. 1841. A herbarium name only, given as a synonym of *Eutriana bromoides*.

Heterostega festucaeformis Bonpl.; Fourn. Mex. Pl. 2: 140. 1881. A herbarium name cited as a synonym of *Atheropogon bromoides*.

Atheropogon radicosus Fourn. Mex. Pl. 2: 140. 1881. *Bourgeau* 450, from Mexico, is the type. This number in the herbaria of the St. Petersburg Botanical Garden, Muséum at Paris, and Botanical Garden of Brussels and in the U. S. National Herbarium has been examined. The specimen at Paris is the type.

^a See discussion after *Bouteloua americana*.

^b Mex. Pl. 2: 140. 1881.

^c For use of this date of publication see Rendle, Journ. Bot. 37: 33. 1899.

DESCRIPTION.

A stout, erect, caespitose, long-lived perennial with stout rhizomatous base, usually in isolated bunches, but occasionally in continuous patches in the southern portion of its range; culms erect, stout, unbranched, 60 to 80 cm. high; sheaths close, strongly striate; blades abundant below and more sparing above, flat, variable in width, mostly 2 to 3 mm. wide, with regularly disposed papillose hairs on the edges; ligule a ciliate fringe of white hairs, about 1 mm. long; spikes loose, variable, often 3 cm. long by about 8 mm. wide or sometimes only 1.5 cm. long, and then resembling those of *Bouteloua filiformis*; spikelets 7 to 10 or sometimes even as much as 11 or 12 mm. long, consisting of 2 florets, the lower perfect, the upper either pistillate or perfect and producing mature seed more often than the lower one; glumes sharply acuminate, the first 4, the second 5 to 6 mm. long; lemma smooth, bone-like, 7 to 8 mm. long, 3-awned, the lateral awns about 1 mm. and the central 2 to 3 mm. long; palea inclosing the caryopsis, scarcely awned, but 1 mm. shorter than the lemma, floret of the same form and texture as that of the lower, 9 to 10 mm. long, with lateral awns 5 to 6 mm. and the central about 1 to 2 mm. longer; palea not differing materially from that of the lower floret; caryopsis about 4 to 5 mm. long, 0.75 to 1 mm. wide, flattened, the scutellum covering four-fifths of the ventral surface. (PLATE 81.)

As stated elsewhere this species grows in the upper foothills and mountains and reaches higher altitudes than the closely related *B. filiformis* with which it is commonly mixed. It differs from that species mainly in being a taller, coarser plant throughout. Its leaves are larger and wider, the culms are larger and stouter, the papillose hairs upon the edges of the leaves are more pronounced and obvious, and the spikes are longer. However, upon plants of *B. radicata* may be found some spikes which might pass for *B. filiformis*, and plants of *B. filiformis* grown in exceptionally favorable localities have spikes as long as some forms of *B. radicata*. It is only in consideration of an aggregation of characters that they can well be distinguished, yet they are in my mind perfectly worthy of being kept apart and are easily distinguishable in the field and usually upon the herbarium sheet as well. *Bouteloua radicata* is found in rather high situations from Arizona and New Mexico to southern Mexico along the continental highland, and extends westward in important quantities especially into Jalisco and Guerrero.^a As in *B. filiformis* there is a great variation in the spikelet. More commonly it is the second floret that is perfect instead of the first. *Tonduz* 13745^b is referred here doubtfully on account of the very small spikes.

HERBARIUM SPECIMENS.

ARIZONA: *Wilcox*, Fort Huachuca in 1894. *Jones* 562, Bowie. *Griffiths & Thorner* 220, Santa Rita Mountains. *MacDougal* 798, Dos Cabezas. *Nealley*, Rincon Mountains.

CALIFORNIA: *Orcutt* in 1884.

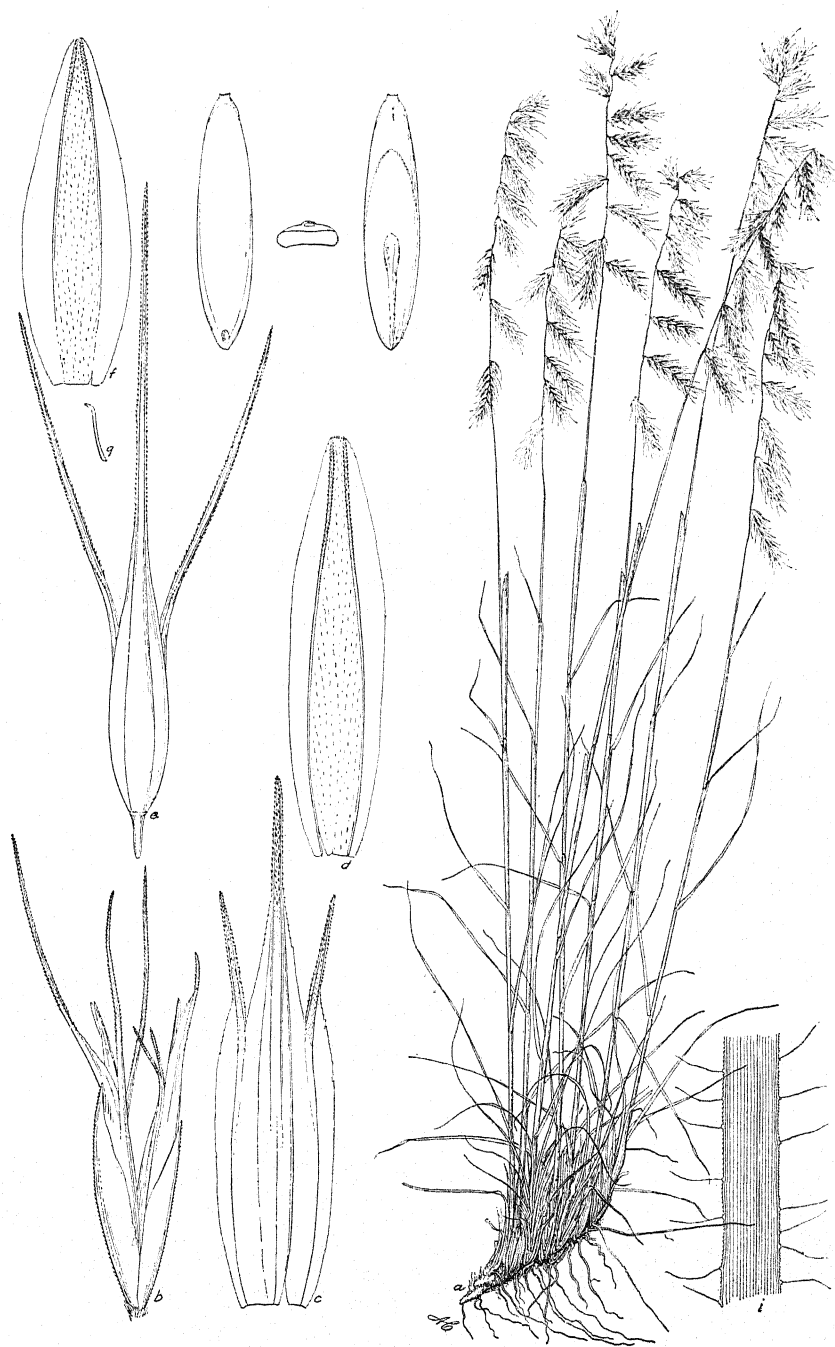
NEW MEXICO: *Wright* 2024. *Smith*, Mangas. *Rusby* 460, Burro Mountains.

MEXICO: *Mearns* 855, south of Bisbee. *Townsend & Baker* 226, Colonia Garcia. *Bourgeau* 450. *Pringle* 1436, Guerrero; 8567, Federal District. *Brandegee* 2 and 57, Cape region, Lower California. *Palmer* 1354, Coahuila, Nuevo León; 301 and 188, Rio Blanco; 115a, Chihuahua; 547, Durango. *Nelson* 2265, San Marcos, Guerrero; 1443 and 1258, valley of Oaxaca; 6258, Colonia Garcia, Chihuahua; 6305, Sierra Madres, Chihuahua. *Rose* 2672, Colotlan, Jalisco.

^a See under *B. americana*.

^b Herb. Inst. fis.-geogr. Costa Rica.

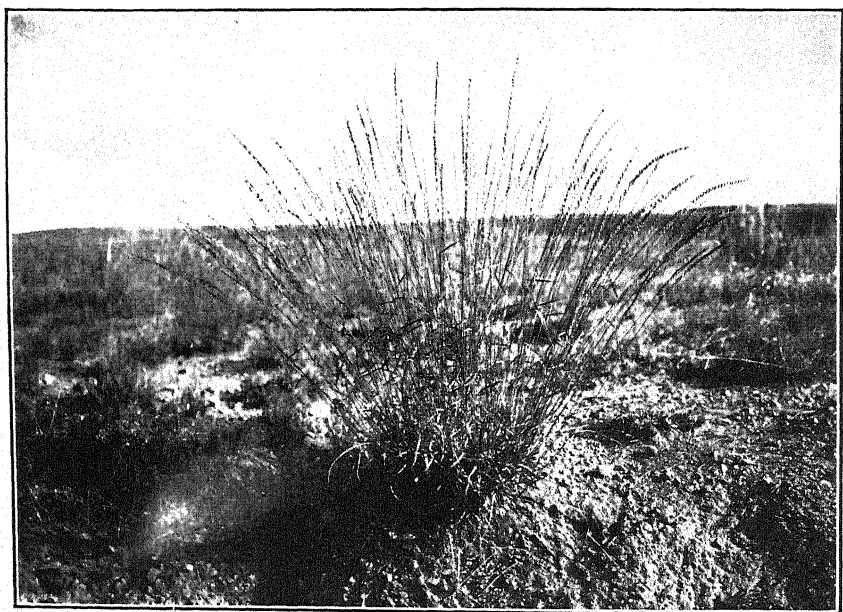
EXPLANATION OF PLATE 81.—a, Habit sketch of *Bouteloua radicata*; b, spikelet; c, d, lemma and palea of first floret; e and f, lemma and palea of second floret; g, prolongation of rachilla; h, two views and cross-section of caryopsis; i, portion of leaf blade. a, One-fourth natural size; b-g, scale 5; h, scale 7.5; i, scale 2.5. From *Griffiths* 7181 and photograph.



BOUTELOUA RADICOSA (FOURN.) GRIFFITHS.



A. *BOUTELOUA FILIFORMIS* (FOURN.) GRIFFITHS.



B. *BOUTELOUA CURTIPENDULA* (MICHX.) TORREY.





BOUTELOUA FILIFORMIS (FOURN.) GRIFFITHS.

31. *Bouteloua filiformis* (Fourn.).

Atheropogon filiformis Fourn. Mex. Pl. 2: 140. 1881. According to Fournier's description and a specimen cited by Fournier, *Liebmann* 585, this is a form with geniculate branching culms of what in this country has passed most commonly for *B. bromoides*. *Karwinski* 991b and *Liebmann* 585 are in the St. Petersburg Botanical Garden, and the latter number is also in the Berlin Herbarium. The type, *Karwinski* 991b, has not been examined.

Vasey^a describes and figures this species under the name *Bouteloua humboldtiana* Kunth.

DESCRIPTION.

An erect and cespitose or geniculate and spreading perennial, with branching culms and with a more limited root system than *B. radicata*; culms erect or spreading, unbranched, 30 to 50 cm. high; sheaths smooth, striate, close; blades narrow, 1.5 to 2 mm. wide, delicate, with papillose hairs regularly distributed upon the margin; ligule a ring of white hairs 1 mm. long or less; spikes commonly 8 mm. wide and 15 mm. long, but often 2 cm. long; spikelets about 10, not pectinate, 12 to 14 mm. long, consisting of one perfect lower floret and an upper staminate one; glumes strongly hispidulously keeled, acuminate-pointed but not awned, nearly equal; lemma about 7 mm. long, hispidulous on the nerves toward the apex, 3-nerved, 3-awned, the lateral awns short and the central 1 mm. longer; palet as long as its lemma, toothed but scarcely awned; rudiment consisting of a well-developed staminate floret with a simple, undivided projection of the rachilla 1 mm. long extending above its insertion; lemma of the staminate floret narrower and more conspicuously awned than that of the lower floret, 7 to 8 mm. long over all, the central awn 1 to 2 mm. longer than the lateral, its palet being about the same as that of the perfect floret; caryopsis about 4 mm. long and 1 mm. wide, the scutellum covering about three-fourths of the ventral surface. (PLATES 82, A, 83.)

The species is variable, especially in habit, and has an extensive range from Texas to California and south into South America. In Arizona and the highland of northern Mexico it is an erect plant.^b

The typical form, that is, the form with geniculate culms growing in favorable situations, is uncommon. There is a slight difference in leafage and color between forms from the United States according as they grow in the deserts, or upon the more fertile soils of southern Texas. In the latter situation, under cover of brush, the whole plant becomes more lax and has a tendency to become geniculate in habit, like the typical form of the species which is familiar to me in western Jalisco.

The following, all from Mexico, appear to be typical of the species: *Liebmann* 585, Consoquitla, and 575, valley of Oaxaca. *Palmer* 1254, Colima; 113, Acapulco; 482, Tamaulipas. *Botteri* 107, Orizaba; *Nelson*, Atlitico, July 25 to August 1, 1903.

HERBARIUM SPECIMENS.

ARIZONA: *Hitchcock* 3499, Tucson; 3692, Patagonia. *Griffiths* 3441, 3386, Santa Rita Forest Reserve; 1470, Rincon Mountains; 1949, Pearce. *Griffiths & Thorner* 3, Santa Rita Forest Reserve. *Leamon* 373. *Mearns* 931, south of Bisbee. *Nealley* 267, Monmouth. *Rothrock* 484, Camp Bowie. *Davis* 562, Clifton. *Chase* 5515, Tucson.

^a U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 40. 1890.

^b See discussion under *Bouteloua americana*.

EXPLANATION OF PLATE 82.—A, *Bouteloua filiformis* in lower foothills in southern Arizona upon stony embankments, growing mainly with *Leptochloa dubia* and *B. curtipendula*. B, *Bouteloua curtipendula*, an uncommonly large bunch from near Greaterville, Arizona.

EXPLANATION OF PLATE 83.—a, Habit sketch of *Bouteloua filiformis*; b, spikelet; c, d, lemma and palet of first floret; e, f, lemma and palet of second floret; g, two views of caryopsis; h, portion of leaf blade. a, One-fourth natural size; b-f, scale 5; g, scale 7.5; h, scale 2.5. From *Griffiths* 7199.

TEXAS: *Havard* 89, Eagle Pass.

MEXICO: *Pringle* 2547, valley of Monterey; *Palmer* 482, Victoria; 1254, Colima; 201, Guaymas; 65, Chihuahua. *Liebmänn* 585, Consoquitla; 575, valley of Oaxaca. *Botteri* 107, Orizaba. *Nelson*, Puebla. *Hartman* 30, Fronteras. *Brandegge* 29, Miraflores, Lower California. *Schumann* 1741, Parral. *Schaffner* 1003, San Luis Potosí. *Rose & Painter* 6538, 6821 (in part) valley of Mexico.

NICARAGUA: *Baker* 2319, Granada.

GUATEMALA: *Heyde & Lux* 628 in J. D. Smith, Plant. Guat. *Deam* 6132, Aguascalientes. *Kellerman* 4784, Department Amatitlan.

YUCATAN: *Schott* 659, 742, Uxmal; 656, Merida.

COSTA RICA: *Tonduz* 13745.

SOUTH AMERICA: *Pittier* 643, State of Cauca, Colombia.

32. *Bouteloua heterostega* (Trin.).

Heterosteca juncifolia Desv. Nouv. Bull. Soc. Philom. Paris **2**: 188. 1810, not *Bouteloua juncifolia* Lag. 1816. In 1813 Desvaux ^a reduces this to a synonym of *Heterosteca americana*, but he was not justified in so doing according to our present conception of species. Kunth ^b appears to have interpreted Desvaux correctly and figures the plant so common in the western portion of the island of Cuba, but made the mistake of including with it *Aristida americana* L. Desvaux's original description of the genus *Heterosteca* would exclude the Linnæan plant.

? *Bouteloua juncifolia* Lag. Gen. & Sp. Nov. 5. 1816. It seems impossible to determine what this is. Lagasca does not mention Desvaux and it does not appear probable to me that he and Desvaux had the same species. Lagasca's type comes from a region to the north of the known distribution of *Bouteloua heterostega* as here interpreted.

? *Actinochloa juncifolia* Roem. & Schult. Syst. Veg. **2**: 420. 1817. Based upon *Bouteloua juncifolia* Lag.

* *Eutriana heterostega* Trin. Gram. Unifl. 242. 1824. Based upon *Heterosteca juncifolia* Desv.

Atheropogon juncifolius Spreng. Syst. Veg. **1**: 294. 1825. Based upon "*Heterostega juncifolia* Desv. et Kunth."

Eutriana juncifolia Kunth, Rév. Gram. **1**: 95. 1829. Based upon *Heterosteca juncifolia* Desv.

? *Eutriana? lagascae* Kunth, Rév. Gram. **1**: 95. 1829. Based upon *Bouteloua juncifolia* Lag.

Dineba juncifolia Beauv.; Steud. Nom. Bot. ed. **2**. **1**: 510. 1840. A name only given as synonym of *Eutriana juncifolia*.

Bouteloua humboldtiana Griseb. Mem. Amer. Acad. n. ser. **8**: 532. 1862. (Pl. Wright. Cub.) The type is *Wright* 734 in the Grisebach Herbarium. Number 739 is also mentioned. *Wright* 739 in the herbarium of the Paris Muséum has both wide and narrow spiked forms on the same sheet. The species is the wide-spiked form typical of *Heterosteca juncifolia* Desv., of which Kunth gave good figures.^b Both numbers are from the island of Cuba. Duplicates of both numbers as well as of *Wright* 3816 (described as a different species) are in the Gray Herbarium. This should not be confused with *Chondrosium humboldtianum* Kunth, which is based upon *Dineba chondrosioides* H. B. K.

Bouteloua porphyrantha Wright, Anal. Acad. Cienc. Habana **8**: 201. 1871; Sauv. Fl. Cub. 192. 1873. The type is a part of *Wright* 739. Duplicates of this number and of the other specimens cited by Grisebach, *Wright* 734 and 3816, are well represented in

^a Journ. de Bot. **1**: 68. 1813.

^b H. B. K. Nov. Gen. & Sp. **1**: 173. pl. 54. 1816.

the Gray Herbarium and in the National Herbarium. Number 739 in the herbarium of the Paris Muséum, as stated above, has, on the same sheet, both wide^a and narrow^b spikes, common in this species.

Atheropogon americanus depauperata[us] Fourn. Mex. Pl. 2: 139. 1881. Fournier cites *Bouteloua juncifolia* Lag. and *Eutriana lagascae* Kunth as synonyms. He mentions two specimens, the first is one from Karwinski in the St. Petersburg Herbarium with neither number nor locality; the other is Wright 739. It is evident from his description and the citation of the last specimen that he had in mind *Bouteloua porphyrantha* Wright. He is evidently wrong in his interpretation of Lagasca.

Heterosteca rhadina Nash, Bull. Torrey Club 30: 386. 1903. Heller's no. 6057, near Ponce, Porto Rico, in the New York Botanical Garden, is the type. Duplicates are widely distributed. Some of these duplicates show the same facts exhibited by Wright 739 in the herbarium of the Paris Muséum.

DESCRIPTION.

Plants mostly low, spreading, sometimes erect, but mostly reclined, and often nearly prostrate and stoloniferous, perennial; culms freely branching; spikes 4 to 10, variable, 1.5 to 3 cm. long, 2 to 6 mm. wide; spikelets 4 to 7, about 12 mm. long including awns, 2-flowered, the lower perfect or pistillate, the upper staminate; glumes nearly equal, scabrous-keeled; lemma of lower floret short-awned, with lateral awns shorter than the central, smooth, coriaceous, about 8 mm. long; lemma of upper floret smooth, coriaceous 10 to 12 mm. long, with long awns, the lateral slightly shorter than the central; palet smooth, 8 mm. long, very short-awned sulcate, on the back between the two nerves, the edges involute; caryopsis about 3 mm. long, 0.7 mm. wide, pointed below and contracted above (immature). (FIGURE 59.)

The species, as it occurs in the West Indies, is very variable in every particular. The spike and spikelet characters are especially subject to variation. The above characterization is drawn from Brother León's no. 861 in so far as spike and details are concerned, amended from Curtiss (West Indian Plants) 546 and others, as to plant characters. The Curtiss specimen in the National Herbarium shows two distinct forms of spikes, one as here described and figured, and the other resembling *B. americana*. Kunth figured^c the wide-spiked form. The majority of the specimens show a true perennial character, while *B. americana* is evidently an annual. In habit and general aspect the species presents all sorts of variations from an erect plant, with branching culms, to a low prostrate plant, with often long-geniculate to prostrate

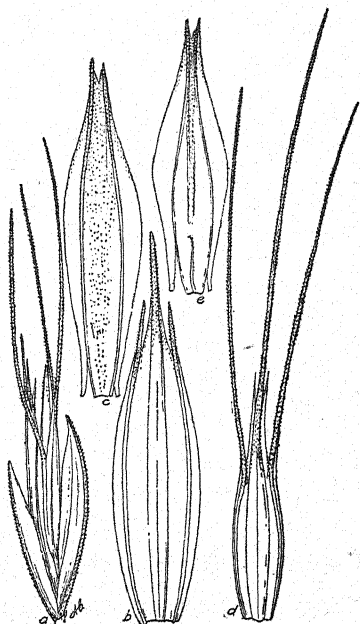


FIG. 59.—*Bouteloua heterostega*. a, Spikelet; b, c, lemma and palet of first floret; d, e, lemma and palet of second floret (rudiment attached to palet). a, Scale 5; b-e, scale 7.5. From León 861.

^a *Bouteloua humboldtiana* Griseb.

^b *Bouteloua porphyrantha* Wright.

^c H. B. K. Nov. Gen. & Sp. 1: 173. pl. 54. 1816.

culms, having profuse proliferations at each node. Rooting often occurs on these nodes making the plants appear stoloniferous, and a short scaly rootstock is sometimes seen, as in the Hitchcock specimen collected at Tricornia, Cuba, March 23, 1906. The Tracy specimen, mentioned below, has spikes with very long awns closely resembling those of *B. radicata*. See discussion under *B. americana*.

HERBARIUM SPECIMENS.

WEST INDIES: *Wright* 739, Cuba; *Hitchcock* 452, Tricornia, Cuba; 460, Playa de Cojimar, Cuba. *Tracy* 9088, Tricornia. *Sintenis* 2269, 2203, and 1959, Porto Rico. *Curtiss* 546, Habana, Cuba. *Duss* 1326, Martinique. *Heller* 6057, Porto Rico. *León* 293 and 861, Habana.

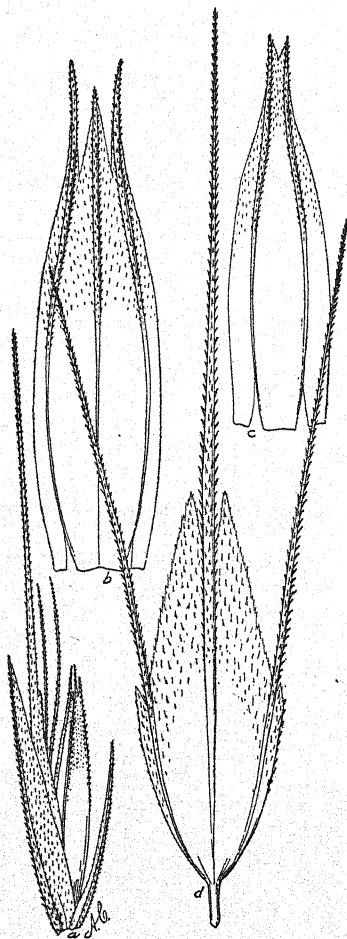


FIG. 60.—*Bouteloua disticha*. *a*, Spikelet; *b*, *c*, lemma and palea of first floret; *d*, rudimentary floret. *a*, Scale 5; *b*–*d*, scale 10. From Schott 741 in Field Museum Herb.

33. *Bouteloua disticha* (H. B. K.) Benth.

Dineba divaricata Beauv. Ess. Agrost. 160. 1812. No description is given; the name appears only in the index, where in his private copy of this work Beauvois has written "=*disticha*," which I interpret to mean *Polyodon distichum* H. B. K.

Polyodon distichum H. B. K. Nov. Gen. & Sp. 1: 175. pl. 55. 1816. I consider the specimens seen to be easily identified from Kunth's figures and description.

Eutriana polyodon Trin. Gram. Unifl. 242. 1824. Based upon *Polyodon distichum* H. B. K.

Atheropogon distichus Spreng. Syst. Veg. 1: 294. 1825. Based upon *Polyodon distichum* H. B. K.

Bouteloua disticha Benth. Journ. Linn. Soc. Bot. 19: 105. 1881. Based upon *Polyodon distichum* H. B. K. See also Field Mus. Bot. 3: 53. 1903.

DESCRIPTION.

An erect, caespitose perennial, about 30 cm. high, with sparingly branched culms; sheaths striate, papillose-hairy, rather loose; blades comparatively broad, flat, scabrous on the edges, with conspicuous papillose hairs, especially toward the base and on the edges; ligule a rather conspicuous collar with a fringe of ciliate hairs; inflorescence racemose; spikes about 25 in number; bilateral but sometimes appearing unilateral, about 1.5 cm. long including awns, spikelets 5 to 8, not pectinate, but more or less

fascicled, the lower being small and mostly rudimentary, but the upper more perfectly developed, the upper florets of the spikelets above the two lower ones usually with long-awned lemmas so disposed as to make the spike appear bilaterally

symmetrical; glumes scabrous-keeled, the first reduced nearly to an awn, 5 mm. long, the second wider, 7 to 8 mm. long; lemma 5 to 6 mm. long, smooth, with 3 short awns, the lateral awns slightly longer than the central; upper floret simply a 3-awned rudiment with a few scales at base or a well-developed perfect floret, but always, except in the lower spikes, bearing a long central awn, the lemma, including awn, 10 to 14 mm. long, the lateral awns often not more than 6 or 7 mm. long. (FIGURE 60.)

The first specimen of this species which I have recognized is *Schott* 741, in the herbarium of the Field Museum of Natural History. The floral characters of *B. disticha* are exceedingly variable, as is true of many of the species of this group. The description is drawn from the upper spikelets. The lower ones are small and often staminate only, the rudiment being reduced to three imperfectly developed, short awns.

The species is exceedingly rare in collections. The chief diagnostic character is the inflorescence and the apparent bilateral arrangement of the spikelets, which is admirably brought out in Kunth's figures.

Besides the Schott specimen the following are typical: *Curtiss* 537, from Cuba; *Pittier* 10374, from Costa Rica; and *León* 299, from Cuba. *Pittier* 2537, Canal Zone, is a geniculate form with branching culms.

34. *Bouteloua pilosa* (Hook.) Benth.

Eutriana pilosa Hook. f. Trans. Linn. Soc. Bot. 20: 173. 1851; Steud. Syn. Pl. Glum. 1: 216. 1854. The Macrae specimen from Albemarle Island, cited by Hooker, has not been examined. My knowledge is based upon *Andersson* 46, from Galapagos, and *Fendler* 2521, from Venezuela, in the Grisebach Herbarium. More recently many fine specimens have been examined in the Gray Herbarium from the Hopkins Galapagos Expedition (*Snodgrass & Heller* 655).

Eutriana gracilis Hook. f. Trans. Linn. Soc. Bot. 20: 175. 1851, not *Bouteloua gracilis* Hook.^a nor Lagasca.^b The type of this species has been examined through the courtesy of the director of the Royal Botanic Gardens of Kew, England.

Bouteloua pilosa Benth.; Wats. Proc. Amer. Acad. 18: 179. 1883. Based upon *Eutriana pilosa* Hook. f.

DESCRIPTION.

An erect, caespitose, smooth annual(?) 20 to 40 cm. high; culms slender, often branching; sheaths close; blades flat, thin, often 10 cm. long, the ligule an inconspicuous ring of short hairs; inflorescence racemose, 10 to 20 cm. long; spikes variable, from 15 to 35, bilateral, on a zigzag rachis, but usually appearing unilateral;

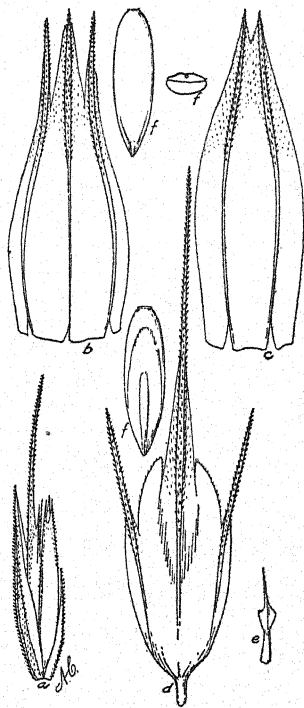


FIG. 61.—*Bouteloua pilosa*. a, Spikelet; b, c, lemma and palea of first floret; d, rudimentary second floret; e, rudimentary floret of lowermost spikelet; f, two views and cross section of caryopsis. a, Scale 5; b-f, scale 10. From *Snodgrass & Heller* 655 in Gray Herb.

^a Vasey in Wheeler, Rep. U. S. Surv. 100th Merid. 6: 287. 1878.

^b Steud. Nom. Bot. ed. 2. 1: 219. 1840.

spikelets 3 to 5, consisting of a lower perfect floret and an upper rudiment; glumes narrow, hispid, keeled, the first about 3 mm., and the second about 5 mm. long, smooth, with 3 short, hispid awns, the central awn not over 0.5 mm. longer than the lateral; palet the same length as its lemma, with two short awns from the two nerves; rudiment usually consisting of a single 3-awned lemma, the central awn being by far the most important, often 9 to 10 mm. long, the lateral awns only 2 mm. long, infolded; caryopsis flattened, 1.75 mm. long, 0.5 mm. wide, the small scutellum covering only about one-third of the ventral surface. (FIGURE 61.)

The description is drawn from *Snodgrass & Heller* 393, James Island, Galapagos, April, 1899. This appears to be a good, average specimen, although it does not cover all of the many variations. The spikelet described is from the middle of the spike. In the lower spikelet the rudiment is usually much smaller than described, at times even reduced to a single awn half as long as the perfect floret. It is exceedingly variable and is more closely related to *B. curtipendula* than to any other species. The Hopkins Galapagos Expedition furnished a fine series of specimens, the best representatives of which are in the Gray Herbarium. Some of them might be considered annual, but no. 507 is clearly perennial. In general aspect this certainly looks like *B. curtipendula*.

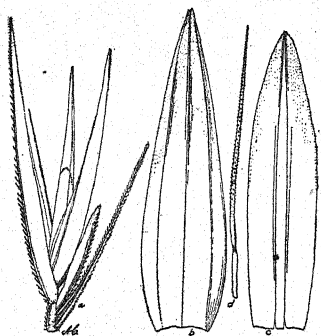


FIG. 62.—*Bouteloua uniflora*. a, Spike, of single spikelet with prolongation of rachis; b, c, lemma and palet; d, rudiment. a, Scale 5; b-d, scale 13. From type specimen.

35. *Bouteloua uniflora* Vasey.

Bouteloua uniflora Vasey, Bot. Gaz. 16:26. 1891. The type is *Nealley* 222, Crockett County, Texas, 1890, in the National Herbarium. See also U. S. Dept. Agr. Div. Agrost. Bull. 7:212. f. 194. 1897.

DESCRIPTION.

A tall, smooth, tufted, erect perennial, with the habit and general appearance of *B. curtipendula*; culms simple or branched at the very base, 35 to 50 cm. high; sheaths striate, smooth or minutely rough-hispid under a lens, the ligule reduced to a ring of short, flexuous, white hairs; blades variable, from 2 to 10 cm. long, the longest above, striate, minutely hispid, especially on the upper surface and on the involute edges, the latter being also sparsely papillose-ciliate; panicle racemose, exactly like that of *B. curtipendula* excepting for the smaller spikes; spikes 25 to 35, 8 to 9 mm. long, consisting of a 1-flowered spikelet and a hispid, closely appressed prolongation of the rachis, about 4 mm. long; second glume 7 to 8 mm. long, 1 mm. wide, acuminate, the first about 3 mm. long, 0.8 mm. wide, with a more rounded apex; lemma smooth, 3-nerved, very short-awned or awnless, about 6 mm. long, with a narrow, 2-toothed, smooth palet, about 5 mm. long; rudiment consisting of a single, simple, hispid awn about 4 mm. long; caryopsis not known. (FIGURE 62.)

The specimen is immature, and it is barely possible that it may turn out to be an aberrant form of *B. curtipendula*. *Bigelow*, "Rio San Pedro, Texas," November 5, 1850, in the herbarium of S. M. Tracy, from the Thurber Herbarium, is the same as the type in every floral detail, but the spikes are more numerous. No collections other than these two have been seen.

36. *Bouteloua curtipendula* (Michx.) Torr.

Chloris curtipendula Michx. Fl. Bor. Amer. 1: 59. 1803. The type, collected in Illinois, is in the Michaux Herbarium.

Bouteloua racemosa Lag. Var. Cienc. 2⁴: 141. 1805. Lagasca cites *Chloris curtipendula* as a synonym in his later paper.^a

Bouteloua pendula "H. R. M." Lag. Var. Cienc. 2⁴: 141. 1805. A garden name published as a synonym of *B. racemosa*.

Atheropogon apludioides Muhl.; Willd. Sp. Pl. 4: 937. 1806; Jacq. Eclog. Gram. 8. pl. 7. 1814; Roem. & Schult. Syst. Veg. 2: 413. 1817; Spreng. Syst. Veg. 1: 293. 1825. A good list of correctly referred synonyms is given by Jacquin.

Bouteloua melicaeformis Brauss.; Hornem. Enum. Pl. Hort. Hafn. 7. 1807. I follow Roemer and Schultes,^b who place this as a synonym under *Atheropogon apludioides*. Only a name is listed.

Bouteloua melicoides Beauv. Ess. Agrost. 40. pl. 9. f. 6. 1812. Based upon "*Bout. melicoides* HORN." (evidently an error for "*melicaeformis*"). Beauvois's figures, however, do not apply to *B. curtipendula*. They resemble more closely some species of the *B. procumbens* group. In his private copy of the Agrostographie Beauvois has written in his own hand "*=Atheropogon apludioides*." This name was later listed, with Muhlenberg as the author, by Steudel^c as a synonym of *Atheropogon apludioides*.

Dineba curtipendula Beauv. Ess. Agrost. 98, 160. 1812. Presumably based upon *Chloris curtipendula* Michx., though Beauvois erroneously cites "*Melica curtipendula* MICHX." See also DC. Cat. Hort. Monsp. 105. 1813 (where the generic name is spelled "*Dinebra*"); H. B. K. Nov. Gen. & Sp. 1: 171. 1816; Presl. Rel. Haenk. 1: 292. 1830.

Dineba melicoides? Beauv. Ess. Agrost. 160. 1812. A name only, given in the index.

Atheropogon racemosus Roem. & Schult. Syst. Veg. 2: 414. 1817. Based upon *Bouteloua racemosa* Lag.

Eutriana curtipendula Trin. Fund. Agrost. 161. 1820. Based upon *Chloris curtipendula* Michx. See also Steud. Syn. Pl. Glum. 1: 215. 1854.

Melica curtipendula Michx.; Steud. Nom. Bot. 1: 91, 519. 1821. Based upon *Chloris curtipendula* Michx. This name was earlier erroneously given by Beauvois (see above under *Dineba curtipendula*).

Bouteloua curtipendula Torr. in Emory, Mil. Recon. 154. 1848; U. S. Dept. Agr. Div. Bot. Bull. 12¹: pl. 43. 1890; Britt. & Brown, Illust. Fl. 1: 180. f. 413. 1896; U. S. Dept. Agr. Div. Agrost. Bull. 7: 213. f. 195. 1897.

Eutriana affinis Hook. f. Trans. Linn. Soc. Bot. 20: 174. 1851; Steud. Syn. Pl. Glum. 1: 215. 1854. The original description states that this is closely allied to *E. curtipendula*. Our present conception of this species would include the form described by Hooker. It is said to be identical with *Atheropogon apludioides*, *Heterostegon curtipendulus*, and *Eutriana curtipendula* of Schweinitz in the Hooker Herbarium. It is based upon Drummond specimens from Missouri and Texas.

Heterostegon curtipendulus Schwein.; Hook. f. Trans. Linn. Soc. Bot. 20: 175. 1851. A name only.

Bouteloua curtipendula aristosa A. Gray, Man. Bot. ed. 2. 553. 1856. This is the typical form in the mountains of the Southwest, but even there the awns often drop off toward maturity. One can establish many varieties in any of these species if he choose, but it appears better not to recognize this form as a subspecies.

Atheropogon curtipendulus Fourn. Mex. Pl. 2: 138. 1881. Based upon *Bouteloua curtipendula* A. Gray. Schaffner 535 and Bourgeau 2755, cited by Fournier, are in the herbarium of the St. Petersburg Botanical Garden.

^a Gen. & Sp. Nov. 5. 1816. ^b Syst. Veg. 2: 414. 1817. ^c Nom. Bot. 1: 117. 1821.

Eutriana racemosa Trin.; Fourn. Mex. Pl. 2: 141. 1881. A name only. According to Hitchcock's notes on the Trinius Herbarium, Trinius's specimen labeled *E. racemosa* is there put in the cover with *B. curtispindula*, to which species it belongs. (See *Triaena gracilis* under *Triaena juncea*.)

Atheropogon affinis Fourn. Mex. Pl. 2: 141. 1881. Based upon *Eutriana affinis* Hook.

DESCRIPTION.

A tall, erect, caespitose perennial, 50 to 80 cm. high, spreading by strong, scaly, creeping rootstocks; sheaths rather close, prominently striate, smooth, the ligule ciliate-fringed; blades abundant, 10 to 30 cm. long, smooth or very minutely scabrous, about equally distributed over the culm; panicle racemose, 15 to 25 cm. long, with

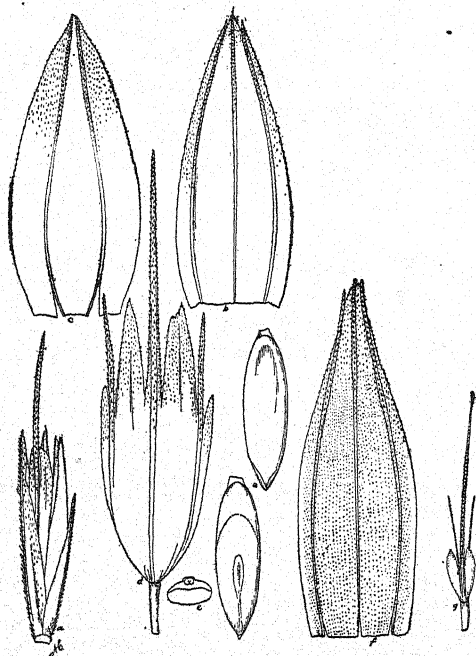


FIG. 63.—*Bouteloua curtispindula*. a, Spikelet; b, c, lemma and palea of first floret; d, rudimentary second floret; e, two views and cross section of caryopsis; f, g, lemma and rudiment from a different plant. a, Scale 5; b-g, scale 8. a-e, From Griffiths 7261; f, g, from Griffiths 7071.

flattened axis; spikes 35 to 50, bilaterally arranged on the flattened axis, but the delicate peduncles so twisted and curved as to make them unilateral, 1 to 2 cm. long; spikelets bilateral on a flattened rachis, but not pectinate, 5 to 8, consisting of one fertile floret and a rudiment; glumes scabrous-keeled, the first 4 to 5 mm., the second about 7 mm. long; lemma minutely 3-awned, the central awn but little longer than the lateral, 5 to 6 mm. long, smooth to slightly scabrous on the nerves toward the apex; palea acuminate, scabrous above; the rudiment reduced to a minute scale with a delicate scabrous awn, and a rudimentary palea consisting of 2 very delicate awns; caryopsis elliptical, about 4.5 mm. long, 1.5 mm. wide, the scutellum covering two-thirds to three-fourths of the ventral surface. (PLATE 69, A, facing p. 345; 82, B, facing p. 413. FIGURE 63.)

The common "side-oat grama" has a distribution in area second only to *B. hirsuta*. It is abundant

from Illinois and Ontario westward and southward far into South America and has been collected as far east as New York and Connecticut. It is an important native forage in many places. Being of good quality and a large, vigorous grower, it is one of the most promising species for domestication, but, like all the others of this genus, it has the important disadvantage of poor seed habits. Besides being produced in small amount, the seed is difficult of separation from the chaff. In all attempts that have been made to establish meadows of it—and there have been a number in an experimental way—no attempts have been made to thrash the seed at all. The spikes, which readily separate from the culms of maturity, have been gathered and sown.

The species is distinct and characteristic, and there are none with which it may be easily confused. Its general aspect is distinct and easily recognized, but the minuter characteristics of the spikelets are most variable. The above description was drawn from *Griffiths* 7071, which corresponds very imperfectly with the drawings of *Griffiths* 7261, published herewith, especially in the character of the rudiment. The latter form is the variety *aristosa*, which it does not seem wise to recognize as a subspecies on account of its extreme variation and the intergradations between it and the typical form.

As would be expected in a plant of such wide distribution, there are great variations in many if not all of the ordinary taxonomic characters. The accompanying text figures show some of these in so far as they relate to the floral structures. As a rule, the general plant body would be pronounced smooth, but often the leaves and sheaths are quite densely papillose-hairy. A specimen collected by Dr. Short in Kentucky ("Knob of the Crab Orchard"), and another, *MacDougal* 273, Flagstaff, Arizona, both show the development of this character. It frequently occurs that the leaves have conspicuously serrate edges or have regularly placed papillose hairs on the edges. *Shear* 707, Osborne, Kansas, is a good example of the development of the latter character. A specimen collected by Eggert in Jefferson County, Missouri, August, 1891, in the herbarium of the Missouri Botanical Garden, has pronounced papillose hairs on the edges of the leaves and very wide spikes, but other plants of the same collection have short spikes and look very peculiar for this species. A specimen in the same herbarium, collected by Bush in McDonald County, Missouri, July 24, 1903, is especially hairy on both the leaves and the sheaths. This condition is to be distinguished from that of the Eggert specimen above. The hairs are papillose also, but occur on the lower side of the leaves and the upper portion of the sheaths. There is none of this in the Eggert specimen. A specimen from Eggert in same herbarium from St. Clair, Illinois, is very similar to the Bush plant.

HERBARIUM SPECIMENS.

ARIZONA: *Blumer* 1671, Chiricahua Mountains. *Hitchcock* 3497, Tucson; 3655, Patagonia. *Tidestrom* 925, Jerome Junction. *Nealley* 1661, Monmouth, Rincon Mountains. *MacDougal* 799, Dos Cabezas; 273, Flagstaff. *Parish* 318. *Chase* 5825, Indian Gardens, Grand Canyon. *Griffiths* 3373, Santa Rita Forest Reserve; 1438, Benson; 1837, Dragoon Mountains; 1907, Cochise. *Holzner* 1569, Huachuca Mountains. *Knowlton* 1961, San Francisco Mountains. *Davidson* 306, Clifton. *Griffiths & Thornber* 188 and 189, Santa Rita Mountains. *Leiberg* 5734, San Francisco Mountains. *Jones* 6066, Canaan Ranch. *Mearns* 859, 1065, south of Bisbee; 1118, San Pedro River, Mexican Boundary. *Zuck* 30, Holbrook.

CALIFORNIA: *Hall* 2138, San Jacinto Mountains.

COLORADO: *Chase* 5310, Manitou; 5408, Las Animas County. *Tidestrom* 66, Hugo. *Clements* (Herb. Form. Colo.) 2. *Crandall* 3541, Fort Collins. *Hitchcock* 1792, Pikes Peak. *Jones* 548, Morrison. *Tweedy* 376, Durango. *Griffiths* 3311, Rocky Ford. *Shear* 969, Canyon City; 948, Salida. *Williams* 2165 and 2120, Colorado Springs. *Baker, Earle & Tracy* 970, Durango.

CONNECTICUT: *Bissell*, Housatonic River near Oxford.

ILLINOIS: *Hill* 181 in 1896, Will County. *V. H. Chase*, 1875, Princeville. *Gleason* 1001, Havana. *McDonald* 60, Peoria. *Skeels* 534, Joliet. *Waite*, Ogle County in 1887. *Wilcox* 62, Manitou.

INDIANA: *Dormer* 58, Elston.

IOWA: *Fink* 433, Fayette. *Morris* A255, Murray to Thayer. *Pammel & Cratty* 756, Ledyard. *Ball* 1008, Manchester. *Pammel* 645, Des Moines.

KANSAS: *Hitchcock* 3852, Manhattan. *Stevens* (in *Seymour's Grasses*) 32, Manhattan. *Smyth* 285, Caldwell; 60, Hutchinson. *Shear* 146, 707, Osborne. *Norton* 910, Riley County. *Thompson* 127, Syracuse; 57, Ulysses.

MICHIGAN: *Wheeler*, Jackson County.

MINNESOTA: *Moyer*, Montevideo. *Mearns* 738, Fort Snelling.

MISSISSIPPI: *Tracy* 1392, Starkville.

MONTANA: *Blankinship* 172, Upper Big Horn River.

NEBRASKA: *Rydborg* 2521, North Platte; 1499, Thomas County. *Clements* 2701, Brazile Creek.

NEW JERSEY: *Van Sickle* (July 27, 1893), Zinc Mines. *Porter*, below Philipsburg.

NEW MEXICO: *Wooton & Standley* 3525, Lincoln County; 3979, Dona Ana County.

Hitchcock 3802, Organ Mountains. *Standley* 4904, San Miguel County. *Fisher* 17, Tucumcari. *Earle* 97 and 94, Gray. *Wooton* 337, Lincoln County; 2945, Fairview; 2922, Santa Fe; 1096, Organ Mountains. *Metcalfe* 640, Mangas Springs. *Mearns* 345, White Water.

NORTH DAKOTA: *Stockbridge* 1875, Fargo. *Brannon* 107, Minot. *Geyer* (1839), near Devils Lake.

NEW YORK: *Wibbe*, Schenectady.

OHIO: *Moseley*, Marblehead.

PENNSYLVANIA: *Commons* 324, Birmingham. *Heller & Halbach* 704, Lancaster County. *Pennell* 569, Chester County.

SOUTH DAKOTA: *Bruce* 14, Jamesville, Yankton County. *Wallace* 9, Indian Creek; 10, Medicine Horse Creek. *Griffiths* 61, Frankfort; 67, Redfield; 285, White Horse Creek; 768, Pierre, 83, Aberdeen. *Wilcox* 4, Brookings.

TEXAS: *Ball* 1152, Chillicothe. *Tracy* 8106, Abilene; 7744, Pierce. *Heller* 1762, Kerrville. *Jermy* 94, San Antonio. *Wright* 756, West Texas. *Hall* 772, Dallas. *Bailey* 741, Guadalupe Mountains. *Plank* 94, Del Rio; 66, El Paso. *Mearns* 1212, Fort Clark. *Lindheimer Exsic.* 568. *Nealley*, College Station.

UTAH: *Jones* 5700, Capitol Wash.

WYOMING: *Chase* 5272, Sundance. *A. Nelson* 530, Whalen Canyon; 8432, Laramie County. *Griffiths* 525, Devils Tower; 697, Newcastle; 494, Sundance; 410, Beulah; *E. Nelson* 479, Laramie County. *Williams* 2587, Sundance.

MEXICO: *Palmer* 503, Jalisco; 114 and 206, Chihuahua; 861, Carmen Island; 371 and 407, Saltillo; 264, Conception del Oro; 194, Durango. *Lloyd* 201, 239, 213, Cedros, Zacatecas. *Hitchcock* 3609, Hermosillo; 3633, Nogales. *Holway* 10, Tula. *Pringle* 408, Chihuahua. *Schumann* 1721, Parral. *Pittier* 444, Esperanza. *Brandege*, San José del Cabo, Lower California. *Mearns* 1039, San José Mountains, Sonora; 2305, near White Water, New Mexico; 520, San Luis Mountains. *Seaton* 113, Orizaba. *Smith* 958, Oaxaca. *Bourgeau* 491, Santa Fé. *Liebmann* 580, Tehuacan. *Orcutt* 671, Topo Mountains, Lower California. *Nelson* 1799, Cuicatlan; 6247, Colonia Garcia, Chihuahua. *Rose* 2929, Bolanos, Jalisco.

CANADA: *Herriot*, Galt, Ontario.

GUATEMALA: *Hyde & Lux* 3930 (in *J. D. Smith's Plants of Guatemala*.)

SOUTH AMERICA: *Bang* 998, Bolivia. *Struckert* 5877, Argentina. *Pittier* 1529, Colombia.

EXCLUDED NAMES.

. The following names belonging to or likely to be looked for in this group are excluded for the reasons enumerated:

Aristida minuta Poit.; Roem. & Schult. Syst. Veg. 2: 711. 1817. Listed as a synonym of *Dineba secunda*.

Aristida secunda Ledeb.; Steud. Nom. Bot. ed. 2. 1: 132. 1840. Given as a synonym of *Eutriana ledebourii*.

Atheropogon antillarum Spreng. Syst. Veg. 1: 294. 1825. *Aristida antillarum* Poir. is cited as a synonym. Probably a species of *Aristida* from the West Indies.

Atheropogon medius Fourn. Mex. Pl. 2: 139. 1881. This may be a form of *Bouteloua aristidioides*, but it can not be determined with any degree of certainty.

Atheropogon villosus Steud. Nom. Bot. ed. 2. 1: 167. 1840. The name is credited to "Nees" and given as a synonym of "*Eutriana villosa*."

Chondrosium virletii Fourn. Mex. Pl. 2: 136. 1881. I have not been able to find authentic material of this, although specimens are cited. The type is Virlet 1373, from San Luis Potosi, Mexico. Some portions of the description suggest a form of *B. trinitii*.

Chondrosium subscorpioides C. Müll. Bot. Zeit. 14: 347. 1856. This is probably *Bouteloua gracilis*, but there is nothing certain about it. It is from California.

Corethrurum Vahl, Skrivt. Naturh.-Selsk (Kjøbenhavn) 6: 85. 1810. This is listed in the Index Kewensis as a synonym of *Bouteloua*, but both the description and the locality (Syria) indicate that it does not belong to this group.

Corethrurum bromoides Vahl, Skrivt. Naturh.-Selsk. (Kjøbenhavn) 6: 85. 1810. The Index Kewensis refers this to *Bouteloua bromoides*, but the description does not admit the plant into this group.

Cynosurus retroflexus Vahl, Symb. Bot. 2: 20. 1791. This is from the East Indies. Both the locality and Vahl's description indicate that it does not belong to this group.

Cynosurus secundus Pursh, Fl. Amer. Sept. 2: 728. 1814. It is not possible for me to identify this from the description. It is probably not a member of our group, although by some it has been referred to *B. curtipendula*. It may be said that *B. curtipendula* is listed by Pursh under two other genera, viz, *Atheropogon* and *Chloris*. Nuttall^a refers this doubtfully to *Atheropogon apludioides*.

Dactylis paspaloides Willd.; Kunth, Rév. Gram. 1: 91. 1829. Given as a synonym of *Leptochloa arabica*. This has been erroneously referred to this group by some authors.

Deyeuxia brasiliensis Steud. Nom. Bot. ed. 2. 1: 620. 1840. A name from Sprengel's herbarium given as a synonym of *Eutriana villosa* according to Trinius's manuscript.

Dinebra Jacq. Fragm. 77. pl. 121. f. 1. 1809. This is a genus of Chlorideae to which various authors have referred species of *Bouteloua*, but which is not allied to this group. Beauvois^b spells the name *Dineba* (the original Arabic spelling) giving Delile as the author, and this spelling is followed by Presl. Kunth spelled the name as did Jacquin.

Dineba aegyptica Delile, Descr. Egypt. 4: 26. pl. 11. f. 3. 1813. This does not belong here, although repeatedly placed here in the past.

Dineba arabica Beauv. Ess. Agrost. 98. pl. 16. f. 2. 1812. The plant figured by Beauvois does not belong in this group. See Bentham's opinion of this.^c

Dinebra brevifolia Steud. Syn. Pl. Glum. 1: 299. 1854. This is from Abyssinia, and probably is not a member of this group.

Dinebra calycina Wight; Nees, Proc. Linn. Soc. 1: 95. 1841. A Wight herbarium name published as a synonym of *Plagiolytrum calycinum*, which is a plant from India.

Dineba chloridea Presl, Rel. Haenk. 1: 291. 1830. According to the specimen at Prague this is not a *Bouteloua*, but probably a *Chloris*.

Dineba lima Beauv. Ess. Agrost. 98. 160. 1812. Beauvois cites this doubtfully under this genus. The combination is made in his index.

Dineba paspaloides Willd.; Beauv. Ess. Agrost. 98, 160. 1812. A name only, probably based upon *Dactylis paspaloides* Willd. Willdenow^d cites *Dinebra arabica* and *Cynosurus retroflexus* as synonyms of *Dactylis paspaloides*.

Dinebra retroflexa Panzer, Denkschr. Akad. Wiss. (München) 4: 270. 1814. Based on *Dactylis paspaloides* Willd.

^a Gen. Pl. 78. 1818.

^b Ess. Agrost. 98. 1812.

^c Journ. Linn. Soc. Bot. 19: 104. 1881.

^d Enum. Pl. 111. 1809.

Dinebra secunda Roem. & Schult. Syst. Veg. 2: 711. 1817. Based upon *Cynosurus secundus* Pursh.

Dinebra verticillata Wight; Steud. Syn. Pl. Glum. 1: 209. 1854. A name cited as synonym of *Leptochloa wightiana*. It is from India and probably not a member of this group.

Enteropogon melicoides Nees; Steud. Syn. Pl. Glum. 1: 216. 1854. A manuscript name published as a synonym of *Eutriana enteropogon*.

Erucaria Cervantes, La Naturaleza (Mexico City) 1: 347. 1870. There is no way of determining with any certainty what the species described are, and consequently they must be rejected. It is not certain that all of the species belong to this group. Cervantes proposed the following names: *Erucaria glandulosa*, *E. villosa*, *E. hirsuta*, *E. lutescens*, *E. monostachia*, *E. tetrastachia*, *E. longifolia*, and *E. glabra*. Fournier has suggested that *E. glabra* is *B. curtispindula*. The description of *E. glandulosa* and *E. hirsuta* both suggest *B. hirsuta*. *Erucaria lutescens* and *E. monostachia* suggest *B. procumbens* or *B. scorpiodes*. *Erucaria villosa* may be *B. chondrosioides*. *Erucaria tetrastachia* may be *B. gracilis*.

Eutriana antillarum Steud. Syn. Pl. Glum. 1: 217. 1854. Based upon "*Aristida antillarum* Lam."

Eutriana? *chloridea* Kunth, Enum. Pl. 1: 280. 1833. Based upon *Dinebra chloridea* Presl.

Eutriana karwinskiana Steud. Nom. Bot. ed. 2. 1: 620. 1840. A name only, from Trinius's manuscript.

Eutriana ledebourii Trin. Gram. Unifl. 238. 1824. Although citing *Dinebra secunda* Roem. & Schult. (*Cynosurus secundus* Pursh) as a synonym, Trinius gives the habitat as St. Domingo. A specimen named *E. ledebourii* in the Trinius Herbarium, is doubtful. The spikelet is that of a *Bouteloua*, but the spikes have but a single spikelet. It does not seem probable, then, that this is the same as *B. americana*, but I am not able to decide without more material.

Eutriana melicoides Steud. Syn. Pl. Glum. 1: 216. 1854. The first synonym cited is an East Indian plant.

Eutriana villosa Steud. Nom. Bot. ed. 2. 1: 620. 1840. No description is given, and the synonyms are only manuscript names.

Ischaemum melicoides Koenig; Willd. Sp. Pl. 4²: 941. 1806; Steud. Syn. Pl. Glum. 1: 216. 1854. Steudel cites this name as a synonym of *Eutriana enteropogon*. The plant is from India and probably does not belong in this group.

Leptochloa arabica Kunth, Rév. Gram. 1: 91. 1829. Based upon *Dinebra arabica* Jacq.

Pappophorum alopecuroideum Vahl, Symb. Bot. 3: 10. pl. 51. 1794. This has been referred to *Bouteloua megapota mica*, but Vahl's figures show it to be true *Pappophorum*.

Tripogon bromoides Roth, Nov. Pl. Sp. Ind. Or. 79. 1821. The generic description excludes *Bouteloua*; Roem. & Schult. Syst. Veg. 2: 600. 1817. An earlier mention of the name based on *Triathera bromoides* Roth in manuscript.

LIST OF SPECIMENS DEPOSITED IN PUBLIC HERBARIA.^a

- Hitchcock 6074. *Triaena juncea*. Tehuacan, Mexico, August 9, 1910.
 Griffiths 8117. *juncea*. Dublan, Hidalgo, Mexico, September 7, 1905.
 8122. *juncea*. Dublan, Hidalgo, Mexico, September 7, 1905.
 8408. *juncea*. Saltillo, Mexico, August 17, 1906.
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- Griffiths 7140. *Bouteloua barbata*. Mount Lemmon, Santa Catalina Mountains, Arizona, September 8-9, 1904.
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- Chase, V.H. 1875. *curtipendula*. Princeville, Peoria County, Illinois, July 8, 1908.
- Griffiths 5614. *curtipendula*. Texline, Texas, August 26-28, 1903.
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- Hitchcock 5827. *Bouteloua filiformis*. Querétaro, Mexico, July 24, 1910.
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- Griffiths 5916. *filiformis*. Santa Rita Mountains, Arizona, October 3, 1903.
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- Wooton 3065. *parryi*. Mesas near Mesilla Park, New Mexico, October 25, 1904.
- Griffiths 5940. *parryi*. Santa Rita Mountains, Arizona, September 27-October 3, 1903.
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- Hitchcock 6780. *Bouteloua radicata*. Balsas, Mexico, September 9, 1910.
- Griffiths 7012. *radicata*. Cultivated at Tucson, Arizona, September 2, 1904.
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- Hitchcock 7040. *repens*. Manzanillo, Mexico, August 20, 1910.
- Griffiths 1556. *rothrockii*. Fort Lowell, Arizona, September, 1900.
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- Griffiths 8460. *scorpioides*. Campero, Mexico, August 30, 1906.
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